UMASS/AMHERST

312066011925928

UNIVERSITY OF MASSACHUSETTS
LIBRARY

LD
3234
M19
v.34-35
1897-98

Date Due

5/17/89

DATE DUE -- 04/01/98
SUBJECT TO:
RECALL

III

bd PRINTED IN U.S.A.

[illegible]
[illegible]
[illegible]
[illegible]

[illegible]

PUBLIC DOCUMENT . . . . No. 31.

THIRTY-FOURTH ANNUAL REPORT

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE.

JANUARY, 1897.

BOSTON:
WRIGHT & POTTER PRINTING CO., STATE PRINTERS,
18 POST OFFICE SQUARE.
1897.

Digitized by the Internet Archive
in 2011 with funding from
Boston Library Consortium Member Libraries

http://www.archive.org/details/annualreport3435mass

CHAPEL–LIBRARY AND DORMITORIES.

PUBLIC DOCUMENT . . . . No. 31.

THIRTY-FOURTH ANNUAL REPORT

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE.

JANUARY, 1897.

BOSTON:
WRIGHT & POTTER PRINTING CO., STATE PRINTERS,
18 POST OFFICE SQUARE.
1897.

639.4
M38
34-35

Commonwealth of Massachusetts.

Massachusetts Agricultural College,
Amherst, Jan. 1, 1897.

To His Excellency Roger Wolcott.

Sir: — I have the honor to transmit, herewith, to Your Excellency and the Honorable Council, the thirty-fourth annual report of the trustees of the Massachusetts Agricultural College.

I am, very respectfully,
Your obedient servant,

HENRY H. GOODELL,
President.

37359

CONTENTS.

PAGE

Calendar, ... 7
Report of trustees, ... 9–26
  Review of thirty years, ... 9
  Expenditure of State appropriations, ... 15
  Courses open to women, ... 16
  Repairs needed, ... 17

Catalogue of officers and students, ... 29
Courses of study, ... 36
  Four-years course, ... 36
  Winter courses, ... 38
  Graduate courses, ... 40

Entrance examination papers, 1896, ... 43
Expenses, ... 49
Labor fund, ... 49
Rooms, ... 50
Scholarships, ... 50

Equipment, ... 51
  Agricultural department, ... 51
  Botanical department, ... 54
  Horticultural department, ... 55
  Zoölogical department, ... 57
  Veterinary department, ... 58
  Mathematical department, ... 59
  Chemical department, ... 61

Reports, ... 65
  Gifts, ... 67
  Treasurer to State, ... 69
  Treasurer to Secretary of Interior, ... 74
  Farm, ... 76
  Military department, ... 85

Monograph on spruce gall-louse, ... 89
Annual report of Hatch Experiment Station, ... 101
  Treasurer, ... 107
  Agriculturist, ... 109
  Meteorologist, ... 150
  Horticulturist, ... 153
  Botanists, ... 157
  Entomologist, ... 185
  Chemist (foods), ... 188
  Chemist (fertilizers), ... 271

CALENDAR FOR 1897–98.

1897.

January 6, Wednesday, winter term begins, at 8 A.M.

March 25, Thursday, winter term closes, at 10.15 A.M.

April 7, Wednesday, spring term begins, at 8 A.M.

June 19, Saturday, Grinnell prize examination of the senior class in agriculture.

June 20, Sunday,	Baccalaureate sermon. Address before the College Young Men's Christian Association.
June 21, Monday,	Burnham prize speaking. Meeting of the alumni. Flint prize oratorical contest.
June 22, Tuesday,	Class-day exercises. Military exercises. Reception by the president and trustees.

June 23, Wednesday, Commencement exercises.

June 24–25, Thursday and Friday, examinations for admission, at 9 A.M., Botanic Museum, Amherst; at Jacob Sleeper Hall, Boston University, 12 Somerset Street, Boston; and at Sedgwick Institute, Great Barrington. Two full days are required for examination, and candidates must come prepared to stay that length of time.

September 7–8, Tuesday and Wednesday, examinations for admission, at 9 A.M., Botanic Museum.

September 9, Thursday, fall term begins, at 8 A.M.

December 23, Thursday, fall term closes, at 10.15 A.M.

1898.

January 5, Wednesday, winter term begins, at 8 A.M.

March 24, Thursday, winter term closes, at 10.15 A.M.

ANNUAL REPORT OF THE TRUSTEES

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE.

His Excellency the Governor and the Honorable Council.

Thirty-five years ago, in the midst of the greatest struggle the world has ever witnessed, when every muscle was being strained to the utmost to provide means for preserving the national existence, our Senators and Representatives in Congress assembled, reversing the old adage, "In time of peace prepare for war," calmly turned aside from the absorbing topics of the day, and in time of war prepared for peace by passing an act for the benefit of agriculture and the mechanic arts, providing for the establishment of national schools of science in every State in this great country. They were to be *colleges*, in which it was explicitly declared the leading object should be, without excluding other scientific and classical studies, and including military tactics, to teach such branches of learning as are related to agriculture and the mechanic arts, in such manner as the Legislatures of the States may respectively prescribe, in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions of life. In such broad and liberal spirit, trammelled by few conditions, was framed this earliest act of Congress for the promotion of national popular education. In the words of the distinguished author himself, the Hon. Justin S. Morrill of Vermont, "the bill proposed to establish at least one college in every State, upon a sure and perpetual foundation, accessible to all, but especially to the sons of toil, where all the needful science for the practical avocations of life shall be taught, . . . and where agriculture, the foundation of all present and future prosperity, may look for troops of earnest friends, studying its familiar and recondite economies, and at last elevating it to that higher level where it may fearlessly invoke comparison with the most advanced standards of the world."

From the sale of the 360,000 acres of the public lands, allotted to Massachusetts, was realized the sum of $208,464, and in 1871 this amount was further increased by the Legislature to $360,000, the whole constituting a perpetual fund for the promotion of education in agriculture and the mechanic arts, two-thirds of the income to be annually paid to the treasurer of the Agricultural College and one-third to the treasurer of the Institute of Technology.

Twenty-five years later, a second great act of Congress established in connection with each college a department of agricultural experimentation, at an annual expenditure of three-fourths of a million dollars.

Again three years, and the Hon. Justin Morrill, with whom had originated the first act, after a careful observance for twenty-eight years of the colleges he had been instrumental in establishing, came forward with a new measure for their endowment, by an annual grant to each one of the same amount, commencing with $15,000 and increasing each year $1,000 till the maximum of $25,000 had been reached, at which figure it was to remain without further increase. This again was divided in Massachusetts, one-third being paid to the Institute of Technology and two-thirds to this college.

Never was there a more munificent gift by a nation in the cause of education. First, ten million acres of the public lands, the proceeds from the sale of which to constitute an inviolable fund for the establishment and maintenance of at least one college in every State which should accept the grant; second, an annual appropriation of three-quarters of a million dollars for purposes of investigation and experimentation in all matters pertaining to the intelligent practice of agriculture; third, an annual appropriation of one million dollars for further maintenance and support. It was a fortunate period in which these colleges were established. The rapid development of the various branches of mechanical and physical science had been accompanied by a corresponding application of them in industrial pursuits and a consequent demand for thoroughly trained and competent men. In the hearing before the committee on education this effect was briefly epitomized. The result was that large numbers of the most promising youth of the country were drawn to these institutions which opened up so many possibilities. This movement gave an impulse which was felt by every school of science in the country. It forced new methods of instruction to meet the constantly increasing demand. It compelled expensive outlays for equipment which should keep pace with this new and practical education of the people. It was the "awakening of a new intellectual life, and there was a certain freshness of interest, a spirit of youth, a generous enthusiasm, which argued the happiest results, and which time has only strengthened as the years roll on." The pet idea of Ezra Cornell, that he would "found an institution where any person could find instruction in any study," would seem to be realized. To-day 65 colleges, thoroughly equipped with laboratories and workshops, and provided with the latest and most approved apparatus, officered by 1,600 professors and instructors, shelter within their walls an army of young men 21,000 strong. Twenty-one regiments, captained and led by the best and keenest intellects available, are all making for progress and development along certain well-defined lines. Five, planting their outposts in every nook and corner of the vast domain of nature, are calling upon the earth, the air, the water to give up their secrets. Sixteen are pushing their way in the various industries, but each and all are making instantly felt the contact of a new and vigorous life and awakening fresh enterprise and fresh effort. Many of the youth composing this vast army receive their entire support from home, but many others are supporting themselves by their own exertions, almost or wholly unaided, and many others come from homes where every dollar contributed to the education of a son or daughter involves some appreciable sacrifice. "They are all acquiring habits of industry, energy and self-reliance. They represent more fully than any other class of institutions the real bone and sinew and brain of the country. They represent in no small degree the brain and purpose of the coming generation. They represent the great body of the people, from which are very largely recruited the best elements of our political, our social and industrial activities." *

Thirty years ago this year the Massachusetts Agricultural College first opened its doors to students, and in this the closing year of its third decade of existence it seems pertinent to inquire whether it has warranted the generous outlay of nation and State for its support, — whether it has fulfilled the purpose for which it was founded, and sent forth honest, manly citizens to serve their country and their State and adorn the different trades and professions of life. The wealth of a college is the life of her sons, and her success is measured by the success of her sons.

In its brief history of one score years and ten, 1,096 men have attended the college and 510 have graduated; 87 have passed away, 15 only from among the graduates and 72 from the remainder. Of the living, 348 are in agricultural pursuits distributed as follows: farmers, 186; farm superintendents, 23; market gardeners and florists, 46; veterinarians, 16; creamery managers, 6; stock and poultry raisers, 10; entomologists, 8; officers in experiment stations, 19; in the fertilizer business, 12; teachers in agricultural colleges, 22. Other industries are represented by chemists, 9; civil engineers and architects, 43; electricians, 10; mechanics, 40; employed on railroads, 15; dentists, 6; druggists, 7; teachers, 34; ministers, 8; students for advanced degrees, 39; postal clerks, 7; doctors, 40; journalists and publishers, 18; in the army and navy, 5; lawyers, 20; and in business, 270. Our graduates are found in every State, filling positions of honor. The record is a good one. We have furnished Japan with 1 president and 7 professors. We have given presidents to Rhode Island and North Dakota and a vice-chancellor to Indiana. We have sent 5 professors to Rhode Island, 2 each to Alabama, Michigan, Ohio, Mississippi, Missouri, Tennessee, Indiana, Connecticut and New Hampshire, and 1 each to Delaware, Minnesota,

---

* From the speech of President George W. Atherton, before the naval committee.

Illinois, Virginia, Maine, Colorado, Texas and Maryland. Yale has drawn upon our lawyers for an instructor in criminal law and medico-legal jurisprudence, Harvard has called our graduates to her veterinary and dental schools, and Canada has found a botanist for Magill University. We have furnished the vice-director to the office of experiment stations at Washington, and directors to Indiana, North Dakota, Vermont, Rhode Island and Brazil, besides filling 63 other positions in the different experiment stations of the country.

Thirty years ago, with a staff of five instructors and four buildings, without a library, without appliances of any sort, the college opened its doors to the 27 young men who presented themselves for admittance. To-day, if one of these same young men should revisit the college, he could but marvel at the change. He will find an opportunity of securing a maximum education at a minimum cost, tuition free, board at a trifling figure and work to be had for the asking, if the necessities of his case demand such aid. He will find a farm of 150 acres under cultivation, with model barn stocked with 100 head of cattle and equipped with the latest and most improved machinery. He will find a horticultural department of 100 acres, with greenhouses, orchards and grounds laid out for the practical study of market gardening, floriculture, fruit culture and forestry. He will find an experiment department, some 80 acres in extent, with laboratories, greenhouses, insectaries and barns, where are being worked out all conceivable problems in the use of fertilizers, in the feeding of animals, in soil investigations, plant diseases, testing of fruits and vegetables, prevention of insect ravages, and relations of temperature and moisture to growth. He will find a growing library of 18,000 carefully selected volumes, almost entirely scientific in its character and well abreast of the literature of the day, in which he will not only be invited and urged to enter, but to which he will be sent to look up information for himself, and taught how to investigate any given subject and to weigh and value the testimony of authorities. He will find a corps of 18 professors and assistants, each doing faithfully and conscientiously the work assigned him. He will find a certain definite required curriculum for three years, with liberty to select and specialize in the fourth; and together with this, eleven short winter courses especially adapted to the requirements of those whom circumstances debar from spending a longer time in the prosecution of their studies. He will find a superstructure of agricultural education, reared somewhat after this fashion: agriculture the foundation; botany, chemistry, zoölogy and mathematics the four corner-stones; while the walls are solidly built up with English, horticulture, floriculture and forestry on the one side, English, physiology, entomology, comparative anatomy of the domestic animals and veterinary on the other, English, mechanics, physics and civil engineering on the third, and English, French, German, political economy and constitutional history on the fourth. The study of his own language, he will find, is made the basis of all study, interwoven with every course, in fact, the very warp and woof of every branch pursued. If he wants to become a farmer, a market gardener or a fruit grower, he will find the appliances at hand and every opportunity to become conversant with the art. If he wants to become a good chemist, every facility will be given him. If he wants to become a good botanist, few places will offer him better instruction. If he wants to become a good entomologist, he will have to search the length and breadth of the land to find equal opportunities. If he wants to become a good civil engineer, the foundations will be laid for him deep and strong. And he will further find, if he inquires, that the course covers such extensive ground in botany, chemistry, physiology and allied branches that graduates entering veterinary or medical schools stand at a great advantage, and in the former case are allowed one year's time. In fact, he will find that the whole aim and purpose of the college has been to so educate its students as to prepare them to play well their part in the "several pursuits and professions of life."

The State has indeed been fortunate in the selection of those to whom it has intrusted the welfare of its college. To the great-hearted men who have carried on this work all credit is due. But for the self-denying, whole-souled efforts of its faculty, such record could never have been written. The living force of men like Clark and Stockbridge and Miller and Peabody and Chadbourne has made it what it is. Their influence can never die.

In the year just elapsed we have been called to mourn the loss of one who has faithfully served the college since 1887. Hon. Joseph A. Harwood of Littleton passed away Oct. 15, 1896. A man of large business interests and wide experience, he held many public offices. Extensively engaged in farming and stock raising, he took an active, intelligent interest in the affairs of the college, conscientiously performing every duty assigned him. In expression of their esteem, the trustees of the college at the first meeting held after his death passed the following resolutions: —

Whereas, Death has removed our associate, Col. Joseph A. Harwood of Littleton, October, 1896, for ten years a member of the Board of Trustees of the Massachusetts Agricultural College, therefore, be it

Resolved, That we now, in annual meeting assembled, place on our records our expression of the high appreciation of his services on the Board, and the esteem in which we shall always hold his memory.

Resolved, That these resolutions be incorporated in the report of the trustees, and that a copy be transmitted to his family.

His place on the Board was filled by the appointment of Charles L. Flint of Brookline. Francis H. Appleton having resigned, Nathaniel I. Bowditch of Framingham was appointed to serve for the remainder of his term.

The several appropriations made by the State have been carefully expended for the purposes named. The Clark property, embracing some 20 acres, has been purchased, and the ground partially prepared for setting out orchards. The addition to the laboratories of the experiment department has been satisfactorily completed. By prolonging the two wings 55 feet, joining them by a transverse section and throwing a sky-light over the intervening space, 1,220 square feet additional room has been secured, much needed for work, and about the same additional space for storing apparatus when not in use, and for exhibiting fertilizer and concentrated food material. The heating apparatus is being rapidly put in position, and a new and improved gas machine, fitted up with a mixing regulator of air and gas, has been purchased. The increasing demands upon the department for analyses of fertilizers and fertilizing materials, water, dairy products and feeds can now be more promptly and efficiently satisfied.

It is too early yet to ascertain how far the eleven short winter courses established this year meet the requirements of those whose circumstances forbid a longer stay at the college. The effort has been made to make them as practical as possible, along such lines as experience has shown to be most helpful. To benefit the many and "to give instruction," as is finely written over one of the archways in the great library at Washington, "to those who cannot procure it for themselves" is the sole aim of these winter courses. In the brief time allotted, the instruction must be more or less elementary in its character; but the double courses provided permit concentrated attention upon a given subject in one year, or continuous study in successive years. The increasing activity of women in the industrial pursuits, and the consequent demand for instruction, has led to the opening of special elective courses for them, in such branches as botany, entomology, floriculture, fruit culture, market gardening and the dairy.

The success attending the elective courses of the senior year has been so marked that an effort is being made, while in no wise departing from the purpose for which the college was founded, to specialize at an earlier point in the course. It is hoped that before another twelve months the adjustment of related studies will have been completed, and the plan submitted for your approval. The study of descriptive geometry in the winter term of junior year has been discontinued, and in its place has been substituted a course of practical work in laboratory physics. An elective course of lectures in history is offered to the senior class.

The two subjects at the present moment lying uppermost in the minds of the farmers and horticulturists of this State are plant diseases and animal diseases. No other questions are of such vital importance; no others affect them more closely. The changed and in some respects unnatural conditions, resulting from forcing plants to produce bloom and fruit out of season, have resulted in the introduction of a large number of new diseases, with which growers under glass find themselves unable to cope. Mildews, fungous growths, nematodes are all doing their deadly work, and many cases have been reported to us where fully one-half the entire crop of cucumbers, tomatoes or lettuce has been ruined. The same holds true in the raising of pinks, violets, roses and other flowers for the market. Statistics show that in 1891 there were 562 persons in Massachusetts engaged in nurseries alone, that some $6,000,000 capital was invested in greenhouses, orchards and nurseries, and that the damage annually done by disease and insect foes was rapidly increasing. The demands made upon college and station for information and relief are unceasing. Scarcely a day passes but diseased plants, spotted leaves or nematode-affected roots are sent in for examination and determination. The college should be in condition to promptly respond to these cries for aid; but the appliances at hand are altogether too meagre for the vast field of inquiry which has been opened. *Common-sense* is a first-class physician, and can take care of the ordinary mumps or measles or scarlet-fever form of disease to which plants are subject; but when it comes to tracing out some new and obscure ailment, trained men are needed. These diseases can only be studied by specialists. They must first be investigated in the laboratory and their life histories made out, and afterwards the different remedies applied in the greenhouse, where the conditions of light, heat, moisture, etc., are under control. The glass houses already on the grounds were built for other ends, and have each their specific work to perform; they cannot be utilized for this purpose. The one attached to the division of vegetable pathology and plant disease is entirely inadequate for such investigations, and requires complete renovation to put it in effective condition. To change its position so that it shall receive the full benefit of the morning and afternoon light, to thoroughly reconstruct and equip it, so that experimentation can be carried on with different diseases at the same time, an appropriation of $1,500 is asked. This amount is based upon plans and contract prices already submitted. The study of botany has entirely changed in character during the last few years. The great object which Bacon proposed to himself in setting forth the advantages of the inductive method of philosophy was *fruit*, the improvement of the condition of mankind. So, now, the study of botany is approached from its utilitarian side, from that side which shall bear fruit and be helpful to mankind. The microscopic structure of the plant itself, the acquaintance with the lower forms of fungous growth, the recognition of disease, have become such important factors that a class room without a laboratory, where the pupil can dissect and investigate for himself, is like a carpenter endeavoring to work without tools. The agricultural college should be especially prepared to give such instruction. Its laboratory, however, is so small that it is found impossible to accommodate a class of over a dozen. Three years ago, before the wants of the department were properly estimated, an appropriation of $200 was asked and granted. It was, however, found to be so entirely inadequate that it was covered back into the State treasury. An appropriation of $1,200 is now asked, to enlarge the laboratory 18 feet, furnish proper light and ventilation and provide the necessary stands and equipment.

Census returns in 1890 place the valuation of domestic animals in this country at over two billion dollars, and it has been computed that there is an annual loss of six per cent. resulting from disease, most of which is preventable. One hundred and twenty million dollars lost annually through carelessness, ignorance or disregard of nature's laws! In 1896 there were in this State 174,167 cows and 38,434 neat cattle other than cows. Horses, sheep and swine swell the total to 485,830 animals. An annual six per cent. loss on the sixteen million dollars valuation of this stock, most of which we are told is preventable, is surely too high a price to pay for lack of knowledge. The report of the veterinarian so clearly sets forth the necessity of providing facilities for enlarging the scope of his department and improving it along certain lines for the benefit of student and citizen that I incorporate it as a part of my report: —

At present the equipment of the department consists of an exceptionally complete collection of papier-maché models, several dissections, dry and alcoholic preparations of normal and diseased tissues, and some charts for class-room work, together with a small room 12 by 15 feet for a laboratory. This contains apparatus consisting of incubator, hot-air and steam sterilizers, microtome, microscope, etc., necessary for ordinary bacteriological and pathological *laboratory* work. The room, being small and having only one window, affords working space for a single person. The nature of the work possible under existing conditions is limited by the want of a suitable place in which to keep such animals as are indispensable for original investigation. The laboratory and its equipment, primarily intended simply for preparing material for the class room, have been employed as far as possible in carrying on the investigations conducted by the department, the results of which have been published in the bulletins of the Hatch Experiment Station. In the past, considerable quantities of material from diseased animals have been sent in by farmers and other persons from various localities in the State. This has been examined, and a report of the same, with brief mention of the cause, means of treating, arresting or preventing the disease, returned to the sender. In those cases where it has been necessary to use animals for experiment in the study required, I have been obliged to keep them in the cellar of my house, for want of a place at the college. With the present arrangements, the simple microscopic study of material is all that can be carried on successfully.

That portion of the Zoölogical Museum set apart for the use of the veterinary department is full to overflowing. There are valuable specimens on hand that cannot be put on exhibition for the want of space. Much that has been placed in the cases cannot be seen to good advantage, owing to the crowded condition.

Briefly stated, under existing conditions the department is confined to two lines of work, viz., instruction to the students in the class room and simple laboratory examinations of such specimens as are sent in by farmers and others. In connection with the former, the material in the museum is utilized for purposes of illustration. Occasional clinical demonstrations are held.

An increase to the equipment of the department would greatly enlarge the scope and value of its work. The first requisite is a laboratory building, including suitable quarters for small animals to be used in experiment. It should also contain a museum, a lecture room, and such accessory rooms as are always necessary in a building of this description. So far as I am aware, there does not exist a place in the State having for its prime object the study of the diseases of the domestic animals. I believe investigations could be made in this line of work at the college, to the great advantage of students, stock owners and veterinarians. Although no special effort has been made to encourage farmers to send material from diseased animals for examination, there have been received from time to time a considerable number of specimens. This division of the work would be enlarged, and valuable assistance rendered the stock raisers and dairymen. There are many of the more remote rural districts in which the services of a competent veterinarian are not available ; in such places the veterinary department of the college could render assistance without doing the practitioner an injustice. Aside from such service rendered directly to the farmer, the same plan could be followed with the veterinarians throughout the State. It frequently happens that there occur in practice obscure cases which the average practitioner has neither the time nor the apparatus to investigate. This is particularly true with some of the contagious diseases, not under control of the State Board of Cattle Commissioners, in which inoculation experiments and careful microscopic examinations are essential to a speedy and correct diagnosis.

In the teaching of veterinary science, as in all others, the "objective method" is particularly valuable. It is impossible for a student to recognize a disease of which he has only a class-room knowledge. Practical demonstration is essential. The use of material sent in during the past few years has proved of great benefit to the students. A laboratory in which each one could study for himself such specimens, as well as the form and habits of the disease producing micro-organisms, would increase the value of the department greatly. To familiarize the agricultural student with the causes, symptoms, diagnosis and prevention of those common maladies which are hereditary and preventable, to familiarize him with the causes, means of propagation and prevention of animal plagues, should be the chief aim in teaching this science in agricultural colleges. This can only be done by combining practical laboratory work with class-room exercises.

With the development of the subject of diagnosis and treatment of disease by the use of bacterial products, the department might properly undertake, for distribution among the farmers, the preparation of such of these substances as should be proven of value. The "bacteriology of the dairy" has been during the past few years the subject of careful study. The good results obtained thus far would seem to indicate the necessity for more extended experiment and research.

From what has already been urged, it must be apparent that more extended quarters are needed for museum purposes. Situated as the college is, in a comparatively small town, the amount of clinical material is necessarily limited, so that at the desired time it is frequently impossible to obtain the fresh specimens needed to supplement class-room work. Under such circumstances a well-stocked museum is indispensable to obtain satisfactory results.

Believing that there is a growing demand for the study of animal pathology and bacteriology, and that the benefits accruing to students, stock raisers, dairymen, poultry producers and others interested in animal industry would be of sufficient magnitude to warrant the cost of construction of suitable buildings and the equipment of the same, I hereby petition the trustees of the college to take the steps requisite for procuring the funds needed to provide the same.

Respectfully submitted,
JAS. B. PAIGE,
Veterinarian.

Plans for buildings especially adapted for this purpose — a laboratory with lecture room and culture room, equipped and complete, with cages for keeping the smaller animals on which experiments are to be tried; a barn, so constructed that patients can be absolutely isolated, and built of such material as to ensure perfect disinfection — would demand a large outlay. The magnitude of the interests at stake, the great value to the community at large, the importance in an educational point of view, warrant such appropriation. It is hoped that at no distant day it may be realized.

Adequate water supply is one of the first requisites in all civilized communities, whether for purposes of sanitation or protection from fire. The present system, inaugurated at the college some twenty-five years ago, fails utterly in both respects. Corrosion and tuberculation of the pipes, and frequent breakages of the main, leave the college at times without any supply whatsoever, so that, if a fire should break out, not a drop of water would be available for the protection of buildings erected by the State at an expense of a quarter of a million of dollars. The diameter of the pipes, only three inches, is entirely too small for the protection of buildings scattered over an area a mile in extent. Twice it has happened that the college has been left without water, for protection from fire, for washing purposes and flushing of the closets, and for the boilers of the electric light plant. It is not only a menace to the health of the students, but a constant danger from fire. The full details are set forth in the report of our civil engineer, herewith submitted: —

Amherst, Mass., Jan. 4, 1897.

President Henry H. Goodell.

Dear Sir: — I submit to you herewith a report of my investigation of the Massachusetts Agricultural College water supply and fire protection, made in accordance with your request.

Present Hydrant Pressure tested.

Dec. 12, 1896, with the assistance of Lieutenant Wright and Mr. Wallace, I tested the water pressure at all of the college hydrants, the method of testing employed being as follows: a siamese, two-way gated coupling, kindly loaned by the Amherst fire department, with a pressure gauge on one of its branches, was attached to the hydrant. By means of it the static pressure at the hydrant was observed, after which fifty feet of rubber-lined hose of fair quality, with one and one-eighth inch conical "smooth" nozzle, was attached to the free branch of the siamese coupling. The water was then allowed to flow, and its pressure at the hydrant was observed again, with the one stream flowing, and note was made of the character and force of the fire stream. From this data was computed the quantity of water discharged per minute. The result of the test of the six above-mentioned hydrants is shown in Table A.

Table A. — *Test of Hydrant Pressure.*

LOCATION OF HYDRANT.	Static Pressure (Pounds per Square Inch).	Pressure and Quantity at Hydrant.*		Horizontal Distance Stream thrown (Feet).	Character.
		Pressure (Pounds).	Gallons per Minute.		
Lower barn (M. A. C.) hydrant,	110	18	135±	50	Broken and no good.
North college (back of) hydrant,	97	22	150±	60+	Broken and no good.
South college hydrant,	92	21	150±	75	Broken and no good.
Drill hall hydrant,	88	21	150±	75	Broken and no good.
Plant house (Durfee) hydrant,	80	36	190±	90	Broken and no good.
Town hydrant, near Bangs house,	87	58	240+	150 to 175	Good.

* With one stream running through fifty feet of two and one-half inch hose and one and one-eighth inch smooth nozzle.

Note. — A good fire stream consists of a discharge of 240 to 250 gallons per minute (through a one and one eighth inch nozzle).

In comment thereon it should be said that at not a single one of the college hydrants was an adequate pressure or quantity of water obtained. With the exception of the stream at the plant house hydrant, which was an indifferent one, all were "feeble" or "very feeble" fire-streams. At the water company's hydrant alone (situated near the Bangs house), of all those tested, was a good fire-stream obtained. It will be further observed, that the valuable Hatch station buildings, laboratories and barns are *absolutely without* fire protection, there being no hydrants nearer than north college, the one and one-quarter inch (reduced to one inch) pipe leading to the station being too small even to supply the laboratories and lavatories at the same time, much less to furnish a fire-stream with which to protect the buildings. The boarding-house, Hatch barn and the Walker's house are in the same plight, while the position of the library and other college buildings, with the present pipe system, is little better.

CAUSE OF INADEQUATE HYDRANT PRESSURE.

The cause of our insufficient water supply is to be found in the small size of our pipes, which under a considerable draught of water so reduce the water pressure, through frictional losses, as to make it impossible to obtain a single good fire-stream at any of the hydrants. It might also be added that the carrying capacity of the present wrought-iron pipe system has no doubt been considerably reduced by corrosion and tuberculation of the inner surfaces of the pipes. The whole college supply is at present delivered through a three-inch wrought-iron pipe laid about twenty years ago, badly corroded, leading from the water company's six-inch main near the Stockbridge house to the drill hall, thence by a four-inch main to the north college hydrant, where it divides, one three-inch branch leading to the barn, the other branch, a two-inch pipe, reduced to one and one-quarter inch (and then one inch), supplying the boarding-house and Hatch station. The plant house, too, is supplied by a three-inch main, which is reduced to one inch leading therefrom to the museum, barn and Professor Maynard's house.

REMEDY.

The remedy for our insufficient water pressure is perhaps obviously the substitution of pipes of larger diameter for our present mains. The present pipes need not be disturbed, but new and larger mains are absolutely necessary, if adequate fire protection is to be obtained. Briefly stated, the proposed changes consist of tapping the water company's main at the junction of the roads near the insectary, and laying a six-inch pipe from this point to the Hatch Experiment Station buildings by way of the road leading by the south end of the pond, past the library, south college, north college and over the ravine to the Hatch station, where the size of the pipe will be reduced to four inches in diameter leading to the feeding barns, etc., on the county road beyond the station. A six-inch branch will be laid to the college barn, with four-inch branches at its extremities, supplying hydrants on the north and south side of the barn. A four-inch branch will be laid to a hydrant opposite the boarding-house, and the water company's six-inch main near the Stockbridge house will be continued to a hydrant near the north-west corner of the botanic museum. Additional hydrants and gates will of course be required and are shown in detail on the plan.

Cost.

The following table (Table B) gives a summarized account of the probable cost of the required improvements, in which is included the purchase of new hose: —

Table B. — *Estimate of Cost of Improvements.*

5,250 feet six-inch cast-iron pipe and specials, furnished and laid,	$3,675 00
1,600 feet four-inch cast-iron pipe and specials, furnished and laid,	800 00
Service-pipe work, new connections, tapping, etc.,	200 00
11 hydrants,	275 00
7 six-inch gates and 2 four-inch gates,	90 00
500 feet hose, fittings, etc.,	300 00
Engineering and supervision ten per cent., nearly, on construction,	460 00
Total,	$5,800 00

Further Improvements advised.

In addition to the above-mentioned improvements, which are deemed imperative, the advisability of still further perfecting our system by the construction of a small reservoir on the hill east of the plant house, and connecting it with our pipe system by a six-inch main, suitably gated, is urged upon you.

The necessity for such a reservoir is found in the inconvenience and danger to which we have been and are repeatedly subjected by the temporary discontinuance of the town water supply, due to breaks in the town main, etc. On several occasions during the past year the college water supply has given out suddenly, and been shut down for so long a period as to necessitate the drawing of fires in our boilers, the shutting down of our electric lighting and power plant, the serious fouling of sewers and closets, with attendant offensiveness and danger of causing sickness among the students, etc., and rendering us absolutely powerless in the event of fire. All of this might be obviated by the construction of a small reservoir on the hill, of a capacity of several days' water supply, which would tide us over the discontinuance of the town water supply, furnishing us not only with the water ordinarily required, but also with a limited fire supply. The additional cost of such improvements would be about $2,500.

Conclusion.

In conclusion, I desire to urge upon you again the advisability of making the first-mentioned improvement, at least. For fire protection our present system is but one step removed from the old-fashioned well and bucket system, in that, while we can get *some* water through a hose, we cannot get it in sufficient quantity or under effective pressure. The long list of past fires at the college, with its attendant losses, is certainly suggestive, if not impressive. Among the buildings wholly or partially destroyed by fire in the past twenty years are the following: the Durfee plant house, main building, was completely destroyed by fire about fourteen years ago; south college, entirely destroyed about eleven years ago; north college has passed through several small fires; the M. A. C. barn was completely destroyed a few years ago, — as was one of the Hatch barns a few years before it. Besides these, there have been numerous other small blazes, unnecessary to chronicle at this time.

Certainly with our present pipe system the hope of making effective resistance against fire is very small.

Respectfully submitted,

LEONARD METCALF.

Recapitulating briefly, the following appropriations are asked : —

1. For renovating the greenhouse in the experiment department of plant disease, ...	$1,500
2. For increasing the educational facilities for teaching botany by providing laboratory room, ...	1,200
3. For painting and renovating the old greenhouses, . .	1,000
4. For providing adequate water supply, laying one mile of six-inch pipe and building a reservoir to be used in emergencies, ...	8,300
Total, ...	$12,000

Respectfully submitted, by order of the trustees,

HENRY H. GOODELL,
President.

Amherst, Jan. 1, 1897.

THE CORPORATION.

	Term expires.
JAMES S. GRINNELL of Greenfield,	1898
CHARLES L. FLINT of Brookline,	1898
WILLIAM H. BOWKER of Boston,	1899
J. D. W. FRENCH of Boston,	1899
J. HOWE DEMOND of Northampton,	1900
ELMER D. HOWE of Marlborough,	1900
NATHANIEL I. BOWDITCH of Framingham,	1901
WILLIAM WHEELER of Concord,	1901
ELIJAH W. WOOD of West Newton,	1902
CHARLES A. GLEASON of New Braintree,	1902
JAMES DRAPER of Worcester,	1903
SAMUEL C. DAMON of Lancaster,	1903
HENRY S. HYDE of Springfield,	1904
MERRITT I. WHEELER of Great Barrington,	1904

Members Ex Officio.

His Excellency Governor ROGER WOLCOTT,
President of the Corporation.

HENRY H. GOODELL, *President of the College.*
FRANK A. HILL, *Secretary of the Board of Education.*
WILLIAM R. SESSIONS, *Secretary of the Board of Agriculture.*

JAMES S. GRINNELL of Greenfield,
Vice-President of the Corporation.

GEORGE F. MILLS of Amherst, *Treasurer.*

CHARLES A. GLEASON of New Braintree, *Auditor.*

Committee on Finance and Buildings.*

JAMES S. GRINNELL.	HENRY S. HYDE.
J. HOWE DEMOND.	SAMUEL C. DAMON.

CHARLES A. GLEASON, *Chairman.*

Committee on Course of Study and Faculty.*

WILLIAM H. BOWKER.	ELMER D. HOWE.
CHARLES L. FLINT.	J. D. W. FRENCH.

WILLIAM WHEELER, *Chairman.*

Committee on Farm and Horticultural Departments.*

ELIJAH W. WOOD.	JAMES DRAPER.
NATHANIEL I. BOWDITCH.	MERRITT I. WHEELER.

WILLIAM R. SESSIONS, *Chairman.*

Committee on Experiment Department.*

CHARLES A. GLEASON.	ELIJAH W. WOOD.
WILLIAM WHEELER.	JAMES DRAPER.

WILLIAM R. SESSIONS, *Chairman.*

Board of Overseers.

STATE BOARD OF AGRICULTURE.

Examining Committee of Overseers.

A. C. VARNUM (*Chairman*), .	OF LOWELL.
GEORGE CRUICKSHANKS, .	OF FITCHBURG.
E. A. HARWOOD, . . .	OF NORTH BROOKFIELD.
JOHN BURSLEY, ...	OF WEST BARNSTABLE.
C. K. BREWSTER, . . .	OF WORTHINGTON.

---

* The president of the college is ex officio a member of each of these committees.

The Faculty.

HENRY H. GOODELL, LL.D., *President*,
Professor of Modern Languages.

LEVI STOCKBRIDGE,
Professor of Agriculture, Honorary.

CHARLES A. GOESSMANN, PH.D., LL.D.,
Professor of Chemistry.

SAMUEL T. MAYNARD, B.SC.,
Professor of Horticulture.

CHARLES WELLINGTON, PH.D.,
Associate Professor of Chemistry.

CHARLES H. FERNALD, PH.D.,
Professor of Zoölogy.

REV. CHARLES S. WALKER, PH.D.,
Professor of Mental and Political Science.

WILLIAM P. BROOKS, B.SC.,*
Professor of Agriculture.

GEORGE F. MILLS, M.A.,
Professor of English and Latin.

JAMES B. PAIGE, D.V.S.,
Professor of Veterinary Science.

LEONARD METCALF, B.S.,
Professor of Mathematics and Civil Engineering.

GEORGE E. STONE, PH.D.,
Professor of Botany.

HERMAN BABSON, M.A.,
Assistant Professor of English.

EDWARD R. FLINT, PH.D.,
Assistant Professor of Chemistry.

---

* On leave.

FRED S. COOLEY, B.Sc.,
Assistant Professor of Agriculture.

RICHARD S. LULL, B.S.
Assistant Professor of Zoölogy

RALPH E. SMITH, B.Sc.,
Instructor in German and Botany.

PHILIP B. HASBROUCK, B.S.,
Assistant Professor of Mathematics.

WILLIAM M. WRIGHT, 1st Lieut., 2d Infantry, U.S.A.,
Professor of Military Science and Tactics.

ROBERT W. LYMAN, LL.D.,
Lecturer on Farm Law.

HENRY H. GOODELL, LL.D.,
Librarian.

Graduates of 1896.*

Master of Science.

Kirkland, Archie Howard, . . .	Norwich.
Smith, Frederic Jason, . . .	North Hadley.

Bachelor of Science.

Burrington, Horace Clifton (Boston Univ.), ...	Charlemont.
Clapp, Frank Lemuel (Boston Univ.),	Dorchester.
Cook, Allen Bradford (Boston Univ.),	Petersham.
De Luce, Francis Edmond (Boston Univ.), ...	Warren.
Edwards, Harry Taylor (Boston Univ.),	Chesterfield.
Fletcher, Stephen Whitcomb (Boston Univ.), ...	Rock.
Hammar, James Fabens (Boston Univ.), ...	Swampscott.
Harper, Walter Benjamin, . . .	Wakefield.
Jones, Benjamin Kent (Boston Univ.),	Middlefield.

---

* The annual report, being made in January, necessarily includes parts of two academic years, and the catalogue bears the names of such students as have been connected with the college during any portion of the year 1896.

Kinney, Asa Stephen (Boston Univ.),	Worcester.
Kramer, Albin Maximilian (Boston Univ.),	Clinton.
Leamy, Patrick Arthur (Boston Univ.),	Petersham.
Marshall, James Laird (Boston Univ.),	South Lancaster.
Moore, Henry Ward (Boston Univ.),	Worcester.
Nutting, Charles Allen (Boston Univ.),	North Leominster.
Pentecost, William Lewis (Boston Univ.),	Worcester.
Poole, Erford Wilson (Boston Univ.),	North Dartmouth.
Poole, Isaac Chester (Boston Univ.),	North Dartmouth.
Read, Frederick Henry (Boston Univ.),	Wilbraham.
Roper, Harry Howard (Boston Univ.),	East Hubbardston.
Saito, Seijiro (Boston Univ.),	Nemuro, Japan.
Sastré de Verand, Salomé (Boston Univ.),	Tabasco, Mexico.
Sellew, Merle Edgar (Boston Univ.),	East Longmeadow.
Shaw, Frederic Bridgman (Boston Univ.),	South Amherst.
Shepard, Lucius Jerry (Boston Univ.),	Oakdale.
Shultis, Newton (Boston Univ.),	Medford.
Tsuda, George (Boston Univ.),	Tok o, Japan.

Dickinson, Asa Williams ('74) (Boston Univ.),	Jersey City, N. J.
Lewis, Henry Waldo ('95) (Boston Univ.),	Rockland.

Total, ... 31

Senior Class.

Allen, Harry Francis,	Northborough.
Allen, John William,	Northborough.
Armstrong, Herbert Julius,	Sunderland.
Barry, John Marshall,	Boston.
Bartlett, James Lowell,	Salisbury.
Cheney, Liberty Lyon,	Southbridge.
Clark, Lafayette Franklin,	West Brattleboro', Vt.
Drew, George Albert,	Westford.
Emrich, John Albert,	Amherst.
Goessmann, Charles Ignatius,	Amherst.
King, Charles Austin,*	East Taunton.

---

* Died at Amherst April 16, 1896, from pneumonia.

Leavens, George Davison,	Brooklyn Heights, N. Y.
Norton, Charles Ayer,	Lynn.
Palmer, Clayton Franklin,	Stockbridge.
Peters, Charles Adams,	Worcester.
Smith, Jr., Philip Henry,	South Hadley Falls.
Total,	16

Junior Class.

Adjemian, Avedis Garrabet,	Kharpoot, Turkey.
Baxter, Charles Newcomb,	Quincy.
Charmbury, Thomas Herbert,	Amherst.
Clark, Clifford Gay,	Sunderland.
Eaton, Julian Stiles,	Nyack, N. Y.
Fisher, Willis Sikes,	Ludlow.
Kinsman, Willard Quincy,	Ipswich.
Montgomery, Jr., Alexander,	Natick.
Nickerson, John Peter,	West Harwich.
Warden, Randall Duncan,	Roxbury.
Wiley, Samuel William,	Amherst.
Wright, George Henry,	Deerfield.
Total,	12

Sophomore Class.

Armstrong, William Henry,	Cambridge.
Beaman, Dan Ashley,	Leverett.
Boutelle, Albert Arthur,	Leominster.
Canto, Ysidro Herrera,	Cansahcat, Yucatan.
Chapin, William Edward,	Chicopee.
Chapman, John Chauncey,	Amherst.
Courtney, Howard Scholes,	Attleborough.
Dana, Herbert Warner,	South Amherst.
Davis, John Alden,	East Longmeadow.
Dickinson, Carl Clifton,	South Amherst.
Dutcher, John Remson,	Nyack, N. Y.
Hinds, Warren Elmer,	Townsend.
Holt, Henry Day,*	Amherst.
Hooker, William Anson,	Amherst.
Hubbard, George Caleb,	Sunderland.
Keenan, George Francis,	Boston.

---

* Killed by accidental discharge of gun at North Hadley, Aug. 5, 1896.

Maynard, Howard Eddy,	Amherst.
Pingree, Melvin Herbert,	Denmark, Me.
Sharpe, Edward Hewett,	Northfield.
Smith, Bernard Howard,	Middlefield.
Smith, Carl William,	Melrose.
Smith, Samuel Eldredge,	Middlefield.
Stacy, Clifford Eli,	Gloucester.
Turner, Frederick Harvey,	Housatonic.
Walker, Charles Morehouse,	Amherst.
Wright, Edwin Monroe,	Manteno, Ill.
Total,	26

Freshman Class.

Atkins, Edwin Kellogg,	North Amherst.
Baker, Howard,	Dudley.
Crane, Henry Lewis,	Ellis.
Crowell, Jr., Charles Augustus,	Everett.
Crowell, Warner Rogers,	Everett.
Frost, Arthur Forrester,	South Monmouth, Me.
Gile, Alfred Dewing,	Worcester.
Halligan, James Edward,	Roslindale.
Harmon, Arthur Atwell,	Chelmsford.
Hull, Edward Taylor,	Greenfield Hill, Conn.
Hunting, Nathan Justus,	Shutesbury.
Kellogg, James William,	Amherst.
Landers, Morris Bernard,	Bondsville.
Lewis, James,	Fairhaven.
March, Allen Lucas,	Ashfield.
Monahan, Arthur Coleman,	South Framingham.
Morrill, Austin Winfield,	Tewksbury.
Munson, Mark Hayes,	Huntington.
Ovalle Barros, Julio Moises,	Santiago, Chile.
Parmenter, George Freeman,	Dover.
Risley, Clayton Erastus,	Plainfield, N. J.
Rogers, William Berry,	Cambridge.
Saunders, Edward Boyle,	Southwick.
Stanley, Francis Guy,	Springfield.
Thompson, George Harris Austin,	Lancaster.
Walker, Henry Earl,	Vineyard Haven.
West, Albert Merril,	Brookville.
Total,	27

Graduates' Two-Years Course.

Alexander, Leon Rutherford,	East Northfield.	
Barrett, Frederick Eugene,	Framingham.	
Capen, Elwyn Winslow,	Stoughton.	
Coleman, Robert Parker,	West Pittsfield.	
Davis, John Alden,	East Longmeadow.	
Dickinson, Harry Porter,	Sunderland.	
Lincoln, Leon Emory,	Taunton.	
Total,		7

Second Year.

Ashley, Henry Simeon,	East Longmeadow.	
Burrington, John Cecil,	Charlemont.	
Colburn, Charles Day,	Westford.	
Dye, Willie Arius,	Sheffield.	
Humphrey, Charles Leonard,	Amherst.	
Merriman, Francis Evander,	Boston.	
Pendleton, Charles Bemis,	Willimansett.	
Perry, Edward King,	Brookline.	
Sastré de Veraud, César,	Tabasco, Mexico.	
Total,		9

Graduate Course.

For Degree of M.S.

Burgess, Albert Franklin,	Rockland.	
Kinney, Asa Stephen,	Worcester.	
Total,		2

Resident Graduates at the College and Experiment Station.

Crocker, B.Sc., Charles Stoughton (Boston Univ.),	Sunderland.
Hammar, B.Sc., James Fabens (Boston Univ.),	Swampscott.
Haskins, B.Sc., Henri Darwin (Boston Univ.),	North Amherst.

Holland, B.Sc., Edward Bertram (Boston Univ.),	Amherst.	
Putnam, B.Sc., Joseph Harry (Boston Univ.),	West Sutton.	
Smith, B.Sc., Robert Hyde (Boston Univ.),	Amherst.	
Thomson, B.Sc., Henry Martin (Boston Univ.),	Monterey.	
Todd, Frederick Gage,	Dorchester.	
White, B.Sc., Edward Albert (Boston Univ.),	Ashby.	
Total,		9

Special Student.

Cross, Edward Winslow,	Manchester, N. H.	
Total,		1

Summary.

Graduate course: —		
For degree of M.S.,	2	
Four-years course: —		
Graduates of 1896,	31	
Senior class,	16	
Junior class,	12	
Sophomore class,	26	
Freshman class,	27	
Two-years course: —		
Graduates of 1896,	7	
Second year,	9	
Resident graduates,	9	
Special student,	1	
Total,		140
Entered twice,		2
Total,		138

FOUR-YEARS COURSE OF STUDY.

Freshman Year.

	Agriculture.	Botany and Horticulture.	Chemistry.	Natural History.	Mathematics.	Latin and English.	French and Social Science.	Drawing and Military.
Fall, . .	- - -	Botany, structural, — 5.	- - -	- - -	Advanced algebra, — 5. Book-keeping, — 2.	English, — 2.	French, — 4.	Study of tactics, — 1.
Winter, .	History of agriculture, soils and soil formation, — 4.	- - -	- - -	- - -	Advanced algebra and geometry (plane), — 4.	English, — 2.	French, — 4	Mechanical drawing, — 6.
Summer, .	Soils: — characteristics, improvement of, drainage, etc., — 4.	Botany, analytical, — 4.	Lectures in elementary chemistry, — 3.	- - -	Geometry (solid), — 3.	English, — 2.	French, — 3.	- -

Sophomore Year.

	Agriculture.	Botany and Horticulture.	Chemistry.	Natural History.	Mathematics.	Latin and English.	French and Social Science.	Drawing and Military.
Fall, . .	Irrigation, disposition of sewage, manures and fertilizers, — 4.	Botany, economic, and laboratory work, — 4.	Lectures in elementary chemistry, — 4.	- - -	Trigonometry, — 3.	English, — 2.	- -	- -
Winter, .	- - -	Laboratory work, — 4.	Lectures and practice, — 4.	Anatomy and physiology, — 4.	Surveying, — 3.	English, — 2.	- -	Mechanical drawing, — 4.
Summer, .	Relations of the atmosphere to plant-life, mowings, pastures, grasses, ensilage, — 5.	Horticulture, — 5.	Dry and humid qualitative analysis, — 3.	- - -	Surveying, — 4.	English, — 2.	- -	- -

JUNIOR YEAR.

	Agriculture.	Botany and Horticulture.	Chemistry.	Zoölogy.	Mathematics.	Latin and English.	French and Social Science.	Drawing and Military.
Fall, . .	Field crops, seed raising, production and improvement of varieties, machines and implements, — 4.	Market gardening, — 3.	Qualitative analysis, — 5.	Zoölogy, laboratory work, — 8.	Physics, — 2.	Rhetoric and composition, — 4.	-	-
Winter, .	Breeds and breeding of live stock, poultry farming, — 2.	-	Lectures and practice in organic chemistry, — 6.	Zoölogy, — 3.	Physics, — 3.	-	English literature, — 4.	Course in laboratory physics, — 4.
Summer, .	-	Landscape gardening, — 5.	The same continued, — 5.	Entomology, — 6.	Physics, — 4.	English, — 2.	-	-

SENIOR YEAR (ELECTIVE).*

Fall, . .	Dairy farming, — 5.	Botany, cryptogamic, — 8.	Chemical physics and quantitative analysis, — 8.	Entomology, — 8. Veterinary science, — 5.	Engineering, — 5. Analytical geometry, — 5.	English, — 2. Advanced English, — 5. Latin, — 5.	Political economy, — 5. German, — 5. History, — 5.	Military science, — 1.
Winter, .	Cattle feeding, — 5.	Botany, cryptogamic, — 8.	Advanced work with lectures, — 8.	Entomology, — 8. Veterinary science, — 5.	Engineering, — 5. Differential calculus, — 5.	English, — 2. Advanced English, — 5. Latin, — 5.	Political economy, — 5. German, — 5. History, — 5.	Military science, — 1. Law lectures, — 1.
Summer, .	Experimental work in agriculture, — 5.	Botany, physiological, — 8.	The same continued, — 8.	Entomology, — 8. Veterinary science, — 5.	Engineering, — 5. Integral calculus, — 5.	English, — 2. Advanced English, — 5. Latin, — 5.	Constitutional history, — 5. German, — 5. History, — 5.	Military science, — 1.

---

* English and military science are required; of the other studies three at least must be chosen.

SHORT WINTER COURSES.

[All courses optional.]

AGRICULTURE.

	I. General Agriculture.	
1.	Soils and operations upon them, drainage, irrigation, etc.,	10
2.	Farm implements and machinery,	5
3.	Manures and fertilizers,	10
4.	Crops of the farm, characteristics, management, etc.,	10
5.	Crop rotation,	2
6.	Farm book-keeping,	5
7.	Agricultural economics,	11
8.	Farm, dairy and poultry management,	11
	Total hours,	64

	II. Animal Husbandry.	
1.	Introduction,	1
2.	Location and soil,	2
3.	Building,	4
4.	Breeds of cattle,*	10
5.	Breeds of horses,	6
6.	Grain and fodder crops,*	11
7.	Foods and feeding,*	11
8.	Extra,	19
	Total hours,	64

* With dairy course.

DAIRYING.

	III. Lectures and Class-room Work.	
1.	The soil and crops,	22
2.	The dairy breeds and cattle breeding,	22
3.	Stable construction and sanitation, care of cattle,	11
4.	Common diseases of stock, their prevention and treatment,	11
5.	Foods and feeding,	11
6.	Book-keeping for the dairy farm and butter factory,	22
7.	Pasteurization and preparation of milk on physicians' prescriptions,	11
	III. Lectures, etc. — Concluded.	
8.	Composition and physical peculiarities of milk; conditions which affect creaming, churning, methods of testing and preservation,	22
9.	Milk testing,	6
10.	Butter making,	12
11.	Practice in aeration, pasteurization,	6
	Total hours,	156

HORTICULTURE.

	IV. Fruit Culture.	
1.	Introduction,	1
2.	Propagation of fruit trees by seed, budding, grafting, forming the head, digging, planting, pruning, training, cultivation, etc.,	28
3.	Insects and fungous diseases,	3
	Total hours,	32

	V. Floriculture.	
1.	Greenhouse construction and heating,	6
2.	Propagation of greenhouse and other plants by seed, cuttings, grafting, etc.,	3
3.	Cultivation of rose, carnation, chrysanthemum and orchids,	12
4.	Propagation and care of greenhouse and bedding plants,	10
	V. Floriculture — Concluded.	
5.	Insects and fungi which attack greenhouse plants,	2
	Total hours,	33

	VI. Market Gardening.	
1.	Introduction, equipment, tools, manures, fertilizers, etc.,	3
2.	Greenhouse construction and heating,	6
3.	Forcing vegetables under glass,	3
4.	Seed growing by the market gardener,	3
5.	Special treatment required by each crop,	10
6.	Insects and fungi, with remedies,	2
	Total hours,	27

BOTANY.

VII. Lectures on Injurious Fungi of the Farm, Garden, Greenhouse, Orchard and Vineyard.

1. Introduction,	2
2. Nature and structure of rusts,	4
3. Nature and structure of smuts,	4
4. Nature and structure of mildews,	4
5. Nature and structure of rots,	4
6. Beneficial fungi of roots,	2
7. Edible mushrooms,	2
Total hours,	22

VIII. Lectures and Demonstrations on "How Plants Grow."

1. Introduction,	1
2. The parts of a plant,	1
3. Structure of the cell and plant in general,	3
4. Functions of root, stem and leaves,	3
5. Food of plant obtained from air,	3
6. Food of plant obtained from soil,	3
7. Transference and elaboration of food,	2
8. Growth of plants,	2
9. Effects of light, moisture, heat and cold,	2
10. Root tubercles on pea and clover,	1
11. Cross fertilization of flowers,	1
Total hours,	22

CHEMISTRY.

IX. General Agricultural Chemistry.

1. Introduction,	2
2. The fourteen elements of agricultural chemistry,	1
3. Rocks and soils,	8
4. The atmosphere,	7
5. The chemistry of crop-growing,	8
6. Fertilizers,	8
7. Animal chemistry,	8
Total hours,	55

X. Chemistry of the Dairy.

1. Introduction,	2
2. The fourteen elements of agricultural chemistry,	14
3. The physical properties of milk,	13
4. Analysis of milk, butter, cheese and other dairy products,	13
5. Chemistry of the manufacture of dairy products,	13
Total hours,	55

ZOÖLOGY.

XI. Animal Life on the Farm.

Total hours,	22

XII. Insect Friends and Foes of the Farmers.

Total hours,	33

GRADUATE COURSE.

1. Honorary degrees will not be conferred.

2. Applicants will not be eligible to the degree of M.S. until they have received the degree of B.Sc. or its equivalent.

3. The faculty shall offer a course of study in each of the following subjects: mathematics and physics; chemistry; agriculture; botany; horticulture; entomology; veterinary. Upon the satisfactory completion of any two of these the applicant shall receive the degree of M.S. This prescribed work may be done at the Massachusetts Agricultural College or at any institution which the applicant may choose; but in either case the degree shall be conferred only after the applicant has passed an examination at the college under such rules and regulations as may be prescribed.

4. Every student in the graduate course shall pay twenty-five dollars to the treasurer of the college before receiving the degree of M.S.

TEXT-BOOKS.

GRAY — "Manual." American Book Company, New York.

DARWIN and ACTON — "Practical Physiology of Plants." University Press, Cambridge.

STRAUSSBERGER — "Practical Botany" Swan, Sonnenschein & Co., London.

SORAUER — "Physiology of Plants." Longmans, Green & Co., New York and London.

GREINER — "How to make the Garden pay." Wm. Maule, Philadelphia.

LONG — "Ornamental Gardening for Americans." Orange Judd Company, New York

TAFT — "Greenhouse Construction" Orange Judd Company, New York.

WEED — "Insects and Insecticides." Orange Judd Company, New York.

WEED — "Fungi and Fungicides." Orange Judd Company, New York.

FULLER — "Practical Forestry." Orange Judd Company, New York.

MAYNARD — "Practical Fruit Grower" Orange Judd Company, New York.

McALPINE — "How to know Grasses by their Leaves" David Douglas, Edinburgh.

LODEMAN — "The Spraying of Crops." Macmillan & Co, New York

SAUNDERS — "Insects injurious to Fruits." Lippincott & Co., Philadelphia.

AIKMAN—"Manures and Manuring." Blackwood & Sons, London.

ARMSBY—"Manual of Cattle Feeding." Wiley & Sons, New York.

MILES—"Stock Breeding" D. Appleton & Co, New York.

CURTIS—"Horses, Cattle, Sheep and Swine." Orange Judd Company, New York.

SHEPARD—"Elementary Chemistry." D. C. Heath & Co., Boston.

STORER—"Agriculture in Some of its Relations to Chemistry." Chas. Scribner's Sons, New York.

RICHTER and SMITH—"Text-book of Inorganic Chemistry." P. Blackiston Son & Co., Philadelphia.

MÜTER—"Analytical Chemistry." P. Blackiston Son & Co., Philadelphia.

ROSCOE—"Lessons in Elementary Chemistry." Macmillan & Co., New York.

BERNTHSEN and MCGOWAN—"Text-book of Organic Chemistry" Blackie & Son, London.

REYNOLDS—"Experimental Chemistry." Longmans, Green & Co., New York and London.

SUTTON—"Volumetric Analysis." J. & A. Churchill, London.

DANA—"Manual of Determinative Mineralogy." John Wiley & Sons, New York.

THOMSON—"Commercial Arithmetic." Maynard, Merrill & Co., New York.

MESERVEY—"Single and Double Entry Book-keeping." Thompson, Brown & Co., Boston.

WELLS—"College Algebra." Leach, Shewell & Sanborn, Boston.

WELLS—"Plane and Solid Geometry." Leach, Shewell & Sanborn, Boston.

WELLS—"Essentials of Trigonometry." Leach, Shewell & Sanborn, Boston.

BOWSER—"Analytic Geometry" D. Van Nostrand Company, New York.

OSBORNE—"Differential and Integral Calculus." Leach, Shewell & Sanborn, Boston.

GAGE—"Principles of Physics." Ginn & Co., Boston.

DAVIS—"Elementary Meteorology." Ginn & Co., Boston.

MERRIMAN and BROOKS—"Handbook for Surveyors." John Wiley & Sons, New York.

JOHNSON—"Theory and Practice of Surveying." John Wiley & Sons, New York.

BYRNE—"Highway Construction." John Wiley & Sons, New York.

SEARLES—"Field Engineering." John Wiley & Sons, New York.

FAUNCE—"Mechanical Drawing." W. J. Schofield, Boston.

FAUNCE—"Descriptive Geometry." Ginn & Co., Boston.

MARTIN—"Human Body" (briefer course). Henry Holt & Co., New York.

WALKER—"Political Economy" (abridged edition). Henry Holt & Co, New York.

WALKER—"Political Economy" (elementary course). Henry Holt & Co., New York.

Lockwood — "Lessons in English." Ginn & Co., Boston.
Genung — "Outlines of Rhetoric." Ginn & Co , Boston.
Sprague — "Six Selections from Irving's Sketch-book." Ginn & Co., Boston.
Wentworth — "Irving's Sketch Book." Allyn & Bacon.
Longfellow — "Poems." Houghton, Mifflin & Co., Boston.
Pattee — "American Literature." Silver, Burdett & Co., Boston.
Painter — "English Literature." Leach, Shewell & Sanborn, Boston.
Pancoast — "Representative English Literature." Henry Holt & Co , New York.
Jevons — "Logic." Science Primer Series. American Book Company, New York.
Whitney — "French Grammar." Henry Holt & Co., New York.
Whitney — "German Grammar." Henry Holt & Co., New York.
Sheldon — "Short German Grammar." D. C. Heath & Co., Boston.
Hodges — "Scientific German" D. C. Heath & Co., Boston.
U. S. Army — "Infantry Drill Regulations."
U. S. Army — "Artillery Drill Regulations."

To give not only a practical but a liberal education is the aim in each department, and the several courses have been so arranged as to best subserve that end. Weekly exercises in composition and declamation are held throughout the course. The instruction in agriculture and horticulture is both theoretical and practical, the lessons of the recitation room being practically enforced in the garden and field. Students are allowed to work for wages during such leisure hours as are at their disposal. Under the act by which the college was founded, instruction in military tactics is imperative, and each student, unless physically debarred,* is required to attend such exercises as are prescribed, under the direction of a regular army officer stationed at the college.

FOUR-YEARS COURSE.

Admission.

Candidates for admission to the freshman class will be examined orally and in writing upon the following subjects: English grammar, geography, United States history, physiology, physical geography, arithmetic, the metric system, algebra (through quadratics), geometry (two books) and civil government (Mowry's "Studies in Civil Government"). The standard required is 65 per cent. on each paper. Diplomas from high schools will *not* be received in place of examination. Examination in the following subjects may be taken a year before the candidate expects to enter college: English grammar, geography, United States history, physical geography and physiology. Satisfactory examination in a substantial part of the subjects offered will be required, that the applicant may have credit for this preliminary examination.

---

* Certificates of disability must be procured of Dr. Herbert B. Perry of Amherst.

Candidates for higher standing are examined as above, and also in the studies gone over by the class to which they desire admission.

No one can be admitted to the college until he is sixteen years of age. The regular examinations for admission are held at the Botanic Museum, at 9 o'clock A.M., on Thursday and Friday, June 24 and 25, and on Tuesday and Wednesday, September 7 and 8; but candidates may be examined and admitted at any other time in the year. For the accommodation of those living in the eastern part of the State, examinations will also be held at 9 o'clock A.M., on Thursday and Friday, June 24 and 25, at Jacob Sleeper Hall, Boston University, 12 Somerset Street, Boston; and for the accommodation of those in the western part of the State, at the same date and time, at the Sedgwick Institute, Great Barrington, by James Bird. Two full days are required for examination, and candidates must come prepared to stay that length of time.

WINTER COURSES.

For these short winter courses examinations are not required. They commence the first Wednesday in January and end the third Wednesday in March. Candidates must be at least sixteen years of age. The doors of the college are opened to applicants from both sexes. The same privileges in regard to room and board will obtain as with other students. Attendance upon general exercises is required. The usual fees for apparatus and material used in laboratory work will be required. Attendance upon military drill is not expected.

ENTRANCE EXAMINATION PAPERS USED IN 1896.

The standard required is 65 per cent. on each paper.

Arithmetic and Metric System.

1. What is the length of a pole that stands $\frac{2}{7}$ in the mud, $\frac{4}{9}$ in the water and 25.5 feet above the water?

2. Reduce to simplest form $\frac{4\frac{3}{4} + \frac{2}{3}}{3\frac{1}{7} - 1\frac{3}{14}} \times 2$.

3. A merchant, after paying 60% of his indebtedness, found that \$3,500 would discharge the remainder. What was his whole indebtedness?

4. If a stationer marks his goods 50% above cost, and then abates 50%, what per cent. does he make or lose?

5. What will \$864.50 amount to in 2 years at 8% compound interest, interest being compounded semi-annually?

6. What is the square root of 1,100,401?

7. In 387 cm., how many feet?

8. The circumference of a circular court is 48 m. 4 dm. How many km. should I walk in going 8 times around it?

9. A rectangular vessel 10 m. × 3 m. × 4 dm. will contain how many litres of water? What will be the weight of this water in grams?

ALGEBRA.

1. Resolve into factors $3x^2+10x+3$.
Resolve into factors $6x^2-31x+35$.

2. A smuggler had a quantity of brandy which he expected would bring him \$198. After he had sold 10 gallons a revenue officer seized one-third of the remainder, in consequence of which the smuggler gets only \$162. Required, the number of gallons he had at first, and the price per gallon.

3. Simplify $\left(\frac{x+1}{x-1}\right)\left(\frac{x+2}{x^2-1}\right)\left(\frac{x-1}{(x+2)^2}\right)$.

4. Rationalize $\frac{\sqrt{1+x^2}-\sqrt{1-x^2}}{\sqrt{1+x^2}+\sqrt{1-x^2}}$.

5. Express with positive exponents and reduce to lowest terms $\left(\frac{a^{-2}b}{a^3b^{-4}}\right)^{-3} \div \left(\frac{ab^{-1}}{a^{-3}b^2}\right)$.

6. $\frac{x+\frac{1}{x}}{x-\frac{1}{x}}+\frac{1+\frac{1}{x}}{1-\frac{1}{x}}=3\tfrac{1}{4}$. Solve for x.

7. Find the square root of

$$\frac{6b}{a}+\frac{6a}{b}-7+\frac{a^3}{b^3}-\frac{3a^2}{b^2}-\frac{3b^2}{a^2}+\frac{b^3}{a^3}.$$

GEOMETRY.

Prove the following propositions: —

1. Two triangles are equal when two sides and the included angle of one are equal to two sides and the included angle of the other.

2. If two parallels are cut by a secant line, the alternate interior angles are equal.

3. The diagonals of a parallelogram bisect each other.

4. The medians of a triangle meet in a common point.

5. In the same circle or equal circles, equal chords subtend equal arcs.

9. The diameter perpendicular to a chord bisects the chord and its subtended arcs.

UNITED STATES HISTORY.

NOTE. — Penmanship, spelling, capitalization and punctuation will be considered in determining the excellence of your paper.

1. Write a short sketch of the life of George Washington.

2. Describe the surrender of Lord Cornwallis at Yorktown at the close of the Revolutionary War.

3. Tell what you can of the rise and fall of the slave power in the United States.

4. What were the "Articles of Confederation?"

5. Write a short sketch of the life of Abraham Lincoln.

6. Give the causes, dates and chief events of the war with Tripoli.

7. Give the events associated with the following dates: 1770, 1789, 1812, 1820, 1848, 1863, 1865, 1893.

8. Give the name of the most famous Confederate commerce destroyer of the Civil War. Tell by whom she was commanded, and relate the circumstances connected with her destruction.

9. Name the Presidents that have held office since the Civil War, giving the dates of each administration.

10. What do you know about the Venezuelan question?

GEOGRAPHY.

NOTE. — Penmanship, spelling, capitalization and punctuation will be considered in determining the excellence of your paper.

1. Describe the geographical features of New England, naming its mountains, lakes, rivers.

2. Describe the Rocky Mountain system.

3. (*a*) Trace the course of the Mississippi River.
   (*b*) Name the States bordering the east bank.

4. Give the capital of Vermont, Rhode Island, New York, Pennsylvania, Ohio, California, Oregon, Texas.

5. Draw a map of Italy and locate Rome, Milan, Venice, Naples

6. Locate Tokyo, Tasmania, Yucatan, Bombay, Sydney.

7. Name the different kinds of government, and give two examples of each kind.

8. Define equator, zone, longitude, latitude, meridian.

9. Describe Alaska, telling of (*a*) its government, (*b*) its geographical features, (*c*) its products.

10. Describe fully the West Indies, telling (*a*) the names of the several islands, (*b*) the class of people, (*c*) the products.

PHYSICAL GEOGRAPHY.

NOTE.—Penmanship, spelling, capitalization and punctuation will be considered in determining the excellence of your paper.

1. What is the difference between physical and political geography?

2. What is a river system, a watershed, an alluvial plain, a delta?

3. What is an ocean current? Give causes of ocean currents.

4. What causes the winds to blow? Define a trade wind, a monsoon and a hurricane.

5. Give a definition of climate. Name three distinct causes thereof.

6. What is a compass? Does the compass always point north? What is the magnetic pole? Is it the same as the north pole?

7. What is a geyser? Where are some of the finest geysers found?

8. Define a glacier, a lateral moraine, a terminal moraine. Where are glaciers found? Name the countries.

9. Describe the formation of a coral island, with its plant and animal life.

10. Of what practical value is the study of physical geography?

CIVIL GOVERNMENT.

NOTE.—Penmanship, spelling, capitalization and punctuation will be considered in determining the excellence of your paper.

1. What is meant by *civil government?* How does it differ from *military government?*

2. By what name is the government of towns, cities or incorporated villages distinguished?

3. In whose hands is the government of a town? What is a *town meeting?* Mention *three* distinct purposes for which a town meeting is held.

4. If you live in a town, mention some of the duties of the selectmen of the town. If you live in a city, mention some of the duties of the mayor of your city.

5. Give the title of any *county* officer chosen by the people, and mention any of his duties. What is the title of the chief executive officer of the State of Massachusetts? What is his name?

6. Who make the laws for the government of the State in which you live? In what bodies is the law-making power vested? How often and where do the law-making bodies meet?

7. How many States are there in the United States? How many States were there when the Constitution was framed? When did the colonies become States?

8. Who make the laws for the government of the United States? How many men from the State of Massachusetts have part in making these laws? Who represents in the national House of Representatives the district in which you live?

9. What is the title of the chief executive officer of the United States? Is he elected directly by the people? Tell how he is elected.

10. What is the judicial power of the United States? In what is it vested?

PHYSIOLOGY.

NOTE. — Penmanship, spelling, capitalization and punctuation will be considered in determining the excellence of your paper.

1. Define a tissue, an organ, a function.

2. Of what is the skeleton composed? Describe the backbone.

3. What is a muscle, and how are the muscles of the body classified?

4. Describe the skin. What are nails and hair? Give their uses.

5. What gives the color to a negro? Where is this color situated? What causes blushing or reddening of the skin in cold weather? Where is this color found?

6. What is a food? What is a poison? Under which head would you class alcohol? Why?

7. Describe the teeth, giving their number and location in the mouth. Give some rules concerning the hygiene of the teeth.

8. Describe in detail the course of the blood throughout the body; name the most important portion of the circulatory system.

9. Give some rules for physical and mental exercise, and tell what would constitute a well-developed man.

10. Name *six* special senses in order of their importance, and name and briefly describe the organ connected with each.

English Grammar and Composition.

Note. — Penmanship, spelling, capitalization and punctuation will be considered in determining the excellence of your paper.

1. Name the parts of speech, define each, and give examples of each.

2. Define (*a*) clause, (*b*) phrase, (*c*) participle, (*d*) infinitive.

3. Give examples of the three kinds of sentences as classified by grammar, naming each kind.

4. Correct the following, stating reasons: —

(*a*) The box of figs were sent to the woman.

(*b*) A room to let for a man fifteen by twenty feet.

(*c*) John ran to see the team in the yard which was being painted.

(*d*) Oh, isn't it a perfectly sublime morning! And I am just dead hungry. Do hurry up and come to breakfast, for we have cherries and I just adore them.

(*e*) Mr. Gray's election was more unanimous than Mr. Brown's.

5. Explain the use of (*a*) the interrogation point, (*b*) the exclamation point, (*c*) the comma, (*d*) the period, (*e*) the quotation marks.

6–8. Describe the town in which you live. Make the account interesting, and write as carefully as possible.

9–10. Write short accounts of the following men. Mention in your accounts some of the works these authors have composed.

(*a*) Washington Irving.
(*b*) Henry W. Longfellow.
(*c*) John Greenleaf Whittier.
(*d*) Nathaniel Hawthorne.

DEGREES.

Those who complete the four-years course receive the degree of Bachelor of Science, the diploma being signed by the governor of Massachusetts, who is the president of the corporation.

Regular students of the college may also, on application, become members of Boston University, and upon graduation receive its diploma in addition to that of the college, thereby becoming entitled to all the privileges of its alumni.

Those completing the graduate course receive the degree of Master of Science.

EXPENSES.

Tuition in advance: —			
Fall term,	$30 00		
Winter term,	25 00		
Summer term,	25 00		
		$80 00	$80 00
Room rent, in advance, $8 to $16 per term,		24 00	48 00
Board, $2 50 to $5 per week,		95 00	190 00
Fuel, $5 to $15,		5 00	15 00
Washing, 30 to 60 cents per week,		11 40	22 80
Military suit,		15 75	15 75
Expenses per year,		$231 15	$371 55

Board in clubs has been about $2.45 per week; in private families, $4 to $5. The military suit must be obtained immediately upon entrance at college, and used in the drill exercises prescribed. The following fees will be charged for the maintenance of the several laboratories: chemical, $10 per term used; zoological, $4 per term used; botanical, $1 per term used by sophomore class, $2 per term used by senior class; entomological, $2 per term used. Some expense will also be incurred for lights and text-books. Students whose homes are within the State of Massachusetts can in most cases obtain a scholarship by applying to the senator of the district in which they live.

THE LABOR FUND.

The object of this fund is to assist those students who are dependent either wholly or in part on their own exertions, by furnishing them work in the several departments of the college. The greatest opportunity for such work is found in the agricultural and horticultural departments. Application should be made to Profs. William P. Brooks and Samuel T. Maynard, respectively in charge of said departments. Students desiring to avail themselves of its benefits must bring a certificate signed by one of the selectmen of the town in which they are resident, certifying to the fact that they require aid.

ROOMS.

All students, except those living with parents or guardians, will be required to occupy rooms in the college dormitories.

For the information of those desiring to carpet their rooms, the following measurements are given: in the new south dormitory the study rooms are about fifteen by fourteen feet, with a recess seven feet four inches by three feet; and the bedrooms are eleven feet two inches by eight feet five inches. This building is heated by steam. In the north dormitory the corner rooms are fourteen by fifteen feet, and the annexed bedrooms eight by ten feet. The inside rooms are thirteen and one-half by fourteen and one-half feet, and the bedrooms eight by eight feet. A coal stove is furnished with each room. Aside from this, all rooms are unfurnished. Mr. Thomas Canavan has the general superintendence of the dormitories, and all correspondence relative to the engaging of rooms should be with him.

SCHOLARSHIPS.

Established by Private Individuals.

Mary Robinson Fund of one thousand dollars, the bequest of Miss Mary Robinson of Medfield.

Whiting Street Fund of one thousand dollars, the bequest of Whiting Street, Esq., of Northampton.

Henry Gassett Fund of one thousand dollars, the bequest of Henry Gassett, Esq., of North Weymouth.

The income of the above funds is assigned by the faculty to worthy students requiring aid.

CONGRESSIONAL SCHOLARSHIPS.

The trustees voted in January, 1878, to establish one free scholarship for each of the congressional districts of the State. Application for such scholarships should be made to the representative from the district to which the applicant belongs. The selection for these scholarships will be determined as each member of Congress may prefer; but, where several applications are sent in from the same district, a competitive examination would seem to be desirable. Applicants should be good scholars, of vigorous constitution, and should enter college with the intention of remaining through the course.

STATE SCHOLARSHIPS.

The Legislature of 1883 passed the following resolve in favor of the Massachusetts Agricultural College: —

Resolved, That there shall be paid annually, for the term of four years, from the treasury of the Commonwealth to the treasurer of the Massachusetts Agricultural College, the sum of ten thousand dollars, to enable the trustees of said college to provide for the students of said institution the theoretical and practical education required by its charter and the law of the United States relating thereto.

Resolved, That annually, for the term of four years, eighty free scholarships be and hereby are established at the Massachusetts Agricultural College, the same to be given by appointment to persons in this Commonwealth, after a competitive examination, under rules prescribed by the president of the college, at such time and place as the senator then in office from each district shall designate; and the said scholarships shall be assigned equally to each senatorial district. But, if there shall be less than two successful applicants for scholarships from any senatorial district, such scholarships may be distributed by the president of the college equally among the other districts, as nearly as possible; but no applicant shall be entitled to a scholarship unless he shall pass an examination in accordance with the rules to be established as hereinbefore provided.

The Legislature of 1886 passed the following resolve, making perpetual the scholarships established: —

Resolved, That annually the scholarships established by chapter forty-six of the resolves of the year eighteen hundred and eighty-three be given and continued in accordance with the provisions of said chapter.

In accordance with these resolves, any one desiring admission to the college can apply to the senator of his district for a scholarship. Blank forms of application will be furnished by the president.

EQUIPMENT.

Agricultural Department.

The Farm. — Among the various means through which instruction in agriculture is given, none exceeds in importance the farm. The part which is directly under the charge of the professor of agriculture comprises about one hundred and fifty acres of improved land and thirty acres of woodland. Of the improved land, about thirty acres are kept permanently in grass. A considerable part of this is laid off in half and quarter acre plats, and variously fertilized with farm-yard and stable manures and chemicals, with a view to throwing light upon the economical production of grass. These plats are staked and labelled, so that all may see exactly what is being used and what are the results.

The rest of the farm is managed under a system of rotation, all parts being alternately in grass and hoed crops. All the ordinary crops of this section are grown, and many not usually seen upon Massachusetts farms find a place here. Our large stock of milch cows being fed almost entirely in the barn, fodder crops occupy a prominent place. Experiments of various kinds are continually under trial; and every plat is staked, and bears a label stating variety under cultivation, date of planting, and manures and fertilizers used.

Methods of land improvement are constantly illustrated here, tile drainage especially receiving a large share of attention. There are now some nine miles of tile drains in successful and very satisfactory operation upon the farm. Methods of clearing land of stumps are also illustrated, a large amount of such work having been carried on during the last few years.

In all the work of the farm the students are freely employed, and classes are frequently taken into the fields; and to the lessons to be derived from these fields the students are constantly referred.

The Barn and Stock. — Our commodious barns contain a large stock of milch cows, many of which are grades; but the following pure breeds are represented by good animals, viz., Holstein-Friesian, Ayrshire, Jersey, Guernsey and Shorthorn. Experiments in feeding for milk and butter are continually in progress. We have a fine flock of Southdown sheep and a few choice specimens of the Shropshire, Horned Dorset, Cotswold and Merino breeds. Swine are represented by the Chester White, Poland China, Middle Yorkshire and Tamworth breeds. Besides work horses, we have a number of pure-bred Percherons, used for breeding as well as for work.

The barn is a model of convenience and labor-saving arrangements. It illustrates different methods of fastening animals, various styles of mangers, watering devices, etc. Connected with it are a plant for electric light and power and commodious storage rooms for vehicles and machines. It contains silos and a granary. A very large share of the work is performed by students, and whenever points require illustration, classes are taken to it for that purpose.

Dairy School. — Connecting with the barn is a wing providing accommodation for practical and educational work in dairying. The wing contains one room for heavy dairy machinery, another for lighter machinery, both large enough to accommodate various styles of all prominent machines; a large ice house, a cold-storage room and a room for raising cream by gravity methods, a class room and a laboratory. The power used is an electric motor. This department is steam heated and piped for hot and cold water and steam. In this department has been placed a full line of modern dairy machinery, so that we are able to illustrate all the various processes connected with the creaming of milk, its preparation for market and the manufacture of butter. Special instruction in such work is offered in the dairy course.

Equipment of Farm. — Aside from machines and implements generally found upon farms, the more important of those used upon our farm and in our barn which it seems desirable to mention are the following: reversible sulky plough, broadcast fertilizer distributer, manure spreader, grain drill, horse corn planter, potato planter, wheelbarrow grass seeder, hay loader, potato digger, hay press, fodder cutter and crusher and grain mill. It is our aim to try all novelties as they come out, and to illustrate everywhere the latest and best methods of doing farm work.

Lecture Room. — The agricultural lecture room in south college is well adapted to its uses. It is provided with numerous charts and lantern slides, illustrating the subjects taught. Connected with it are two small rooms at present used for the storage of illustrative material, which comprises soils in great variety, all important fertilizers and fertilizer materials, implements used in the agriculture of our own and other countries, and a collection of grasses and forage plants, grains, etc.

A valuable addition to our resources consists of a full series of Landsberg's models of animals. These are accurate models of selected animals of all the leading breeds of cattle, horses, sheep and swine, from one-sixth to full size, according to subject. We are provided with a complete collection of seeds of all our common grasses and the weeds which grow in mowings, and have also a large collection of the concentrated food stuffs. All these are continually used in illustration of subjects studied.

Museum. — An important beginning has been made towards accumulating materials for an agricultural museum. This is to contain the rocks from which soils have been derived, soils, fertilizer materials and manufactured fertilizers, seeds, plants and their products, stuffed animals, machines and implements. It is expected to make this collection of historical importance by including in it old types of machines and implements, earlier forms of breeds, etc. For lack of room the material thus far accumulated is stored in a number of scattered localities, and much of it where it cannot be satisfactorily exhibited.

BOTANICAL DEPARTMENT.

Course of Study. — This department is well equipped to give a comprehensive course in most of the subjects of botany. The course aims to treat of all the more important features connected with the study of plants which have a close bearing upon agriculture, without at the same time deviating from a systematic and logical plan. Throughout the entire course the objective methods of teaching are followed, and the student is constantly furnished with an abundance of plant material for practical study, together with an elaborate series of preserved specimens for illustration and comparison. In the freshman year the study of structural and systematic botany is pursued, with some observation on insect fertilization. This is followed in the first term of the sophomore year by the systematic study of grasses, trees and shrubs, and this during the winter term by an investigation into the microscopic structure of the plant. The senior year is given up entirely to cryptogamic and physiological botany.

The Botanical Museum contains the Knowlton herbarium, of over ten thousand species of phanerogamous and the higher cryptogamous plants; about five thousand species of fungi, and several collections of lichens and mosses, including those of Tuckerman, Frost, Denslow, Cummings, Müller and Schaerer. It also contains a large collection of native woods, cut so as to show their individual structure; numerous models of native fruits; specimens of abnormal and peculiar forms of stems, fruits, vegetables, etc.; many interesting specimens of unnatural growths of trees and plants, natural grafts, etc.; together with models for illustrating the growth and structure of plants, and including a model of the squash which raised by the expansive force of its growing cells the enormous weight of five thousand pounds.

The Botanical Lecture Room, in the same building, is provided with diagrams and charts of over three thousand figures, illustrating structural, systematic and physiological botany.

The Botanical Laboratory, with provision for sixteen students to work at one time, is equipped with Leitz', Reichert's, Bausch and Lomb's, Beck's, Queen's and Tolles' compound microscopes, with objectives varying from four inch to one-fifteenth inch focal length. It also contains a Du Bois-Reymond induction apparatus and rheocord, a Lippmann capillary electrometer, a Thoma, a Minot and a Beck microtome, a self-registering thermometer and hygrometer, a Wortmann improved clinostat and also one of special construction, an Arthur centrifugal apparatus with electric motor, a Pfeffer-Baranetzky electrical self-registering auxanometer, a Sach's arc-auxanometer, a horizontal reading microscope (Pfeffer model), various kinds of dynamometers of special construction, respiration appliances, mercurial sap and vacuum gauges, manometers, gas and exhaust chambers, a Bausch and Lomb microphotographic camera, a Clay landscape camera and dark closet fitted for work, besides various other appliances for work and demonstration in plant physiology.

Horticultural Department.

Greenhouses. — To aid in the instruction of botany, as well as that of floriculture and market gardening, the glass structures contain a large collection of plants of a botanical and economic value, as well as those grown for commercial purposes. They consist of a large octagon, forty by forty feet, with sides twelve feet high and a central portion over twenty feet high, for the growth of large specimens, like palms, tree ferns, the bamboo, banana, guava, olive, etc.; a lower octagon, forty by forty feet, for general greenhouse plants; a moist stove twenty-five feet square; a dry stove of the same dimensions; a rose room, twenty-five by twenty feet; a room for aquatic plants, twenty by twenty-five feet; a room for ferns, mosses and orchids, eighteen by thirty feet; a large propagating house, fifty by twenty-four feet, fitted up with benches sufficient in number to accommodate fifty students at work at one time; a vegetable house, forty-two by thirty-two feet; two propagating pits, eighteen by seventy-five feet, each divided into two sections for high and low temperatures, and piped for testing overhead and under-bench heating; a cold grapery, eighteen by twenty-five feet. To these glass structures are attached three workrooms, equipped with all kinds of tools for greenhouse work. In building these houses as many as possible of the principles of construction, heating, ventilating, etc., have been incorporated for the purposes of instruction.

Orchards. — These are extensive, and contain nearly all the valuable leading varieties, both old and new, of the large fruits, growing under various conditions of soil and exposure.

Small Fruits. — The small-fruit plantations contain a large number of varieties of each kind, especially the new and promising ones, which are compared with older sorts, in plots and in field culture. Methods of planting, pruning, training, cultivation, study of varieties, gathering, packing and shipping fruit, etc., are taught by field exercises, the students doing a large part of the work of the department.

Nursery. — This contains more than five thousand trees, shrubs and vines in various stages of growth, where the different methods of propagation by cuttings, layers, budding, grafting, pruning and training are practically taught to the students.

Garden. — All kinds of garden and farm-garden crops are grown in this department, furnishing ample illustration of the treatment of market-garden crops. The income from the sales of trees, plants, flowers, fruit and vegetables aids materially in the support of the department, and furnishes illustrations of the methods of business, with which all students are expected to become familiar.

Forestry. — Many kinds of trees suitable for forest planting are grown in the nursery, and plantations have been made upon the college grounds and upon private estates in the vicinity, affording good examples of this most important subject. A large forest grove is connected with this department, where the methods of pruning trees and the management and preservation of forests can be illustrated. In the museum and lecture-room are collections of native woods, showing their natural condition and peculiarities; and there have been lately added the prepared wood sections of R. B. Hough, mounted on cards for class-room illustration.

Ornamental trees, shrubs and flowering plants are grouped about the grounds in such a way as to afford as much instruction as possible in the art of landscape gardening. All these, as well as the varieties of large and small fruits, are marked with conspicuous labels, giving their common and Latin names, for the benefit of the students and the public.

Tool House. — A tool house, thirty by eighty feet, has been constructed, containing a general store-room for keeping small tools; a repair shop with forge, anvil and work-bench; and a carpenter shop equipped with a large Sloyd bench and full set of tools. Under one-half of this building is a cellar for storing fruit and vegetables. In the loft is a chamber, thirty by eighty feet, for keeping hot-bed sashes, shutters, mats, berry crates, baskets and other materials when not in use.

Connected with the stable is a cold-storage room, with an ice-chamber over it, for preserving fruit, while the main cellar underneath the stable is devoted to the keeping of vegetables.

All the low land south of the greenhouses has been thoroughly underdrained and put into condition for the production of any garden or small fruit crop.

Zoölogical Department.

Zoölogical Lecture Room. — The room in south college is well adapted for lecture and recitation purposes, and is supplied with a series of zoölogical charts prepared to order, also a set of Leuckart's charts, disarticulated skeletons and other apparatus for illustration.

Zoölogical Museum. — This is in immediate connection with the lecture room, and contains the Massachusetts State collection, which comprises a large number of mounted mammals and birds, together with a series of birds' nests and eggs, a collection of alcoholic specimens of fishes, reptiles and amphibians, and a collection of shells and other invertebrates.

There is also on exhibition in the museum a collection of skeletons of our domestic and other animals, and mounted specimens purchased from Prof. H. A. Ward; a series of glass models of jelly fishes, worms, etc., made by Leopold Blaschka in Dresden; a valuable collection of corals and sponges from Nassau, N. P., collected and presented by Prof. H. T. Fernald; a fine collection of corals, presented by the Museum of Comparative Zoölogy in Cambridge; a collection of alcoholic specimens of invertebrates from the coast of New England, presented by the National Museum at Washington; a large and rapidly growing collection of insects of all orders; and a large series of clastic models of various animals, manufactured in the Auzoux laboratory in Paris.

It is the purpose of those in charge to render the museum as valuable to the student as possible; and with this end in view the entire collection has been rearranged so as to present a systematic view of the entire animal kingdom, with special regard to the fauna of Massachusetts. In the furtherance of this idea a special case has been prepared, in which are shown typical animals in such a way as to give a brief synopsis of the entire animal kingdom, forming a sort of index to the museum as a whole. In order to render our collection complete, particularly with reference to Massachusetts forms, we would gratefully receive donations of any sort, either alcoholic or otherwise preserved, especially among the worms, fishes, amphibians or reptiles. Specimens should be sent care of Prof. R. S. Lull. The museum is now open to the public from three to four P.M. every day except Sunday.

Zoölogical Laboratory. — A large room in the laboratory building has been fitted up for a zoölogical laboratory, with tables, sink, gas, etc., and is supplied with a reference library, microscopes, chemical and other necessary apparatus for work. This laboratory with its equipment is undoubtedly the most valuable appliance for instruction in the department of zoölogy.

Entomological Laboratory. — The new entomological laboratory adjoining the insectary, with its complete equipment, furnishes most excellent opportunities to study practical and scientific entomology. This building comprises a laboratory which occupies the whole northern and eastern portion of the first floor, which is well supported by piers and bridging to prevent, as far as possible, any jar that would interfere with the microscopical or other delicate work that may be going on. The room is equipped with all the apparatus necessary for the needs of the student, and he also has access to the insectary, where he can study the biological collection of insects and also observe the experimental work and investigations made on injurious insects. The library of the insectary, which is accessible to the students, contains all the leading works on entomology and also a very complete card catalogue of the literature of North American insects.

The second floor of the laboratory contains a photographing room with a dark room adjoining, private laboratories for graduate or undergraduate students who may be doing special work, while the attic furnishes ample store room. The entire building, including the insectary and greenhouse, is heated with a hot-water system and supplied with electric lights.

Veterinary Department.

This department is well equipped with the apparatus necessary to illustrate the subject in the class room.

It consists of an improved Auzoux model of the horse, imported from Paris, constructed so as to separate and show in detail the shape, size, structure and relations of the different parts of the body; two *papier-maché* models of the hind legs of the horse, showing diseases of the soft tissues, — wind-galls, bogs, spavins, etc., also the diseases of the bone tissues, — splints, spavins and ringbones; two models of the foot, one according to Bracy Clark's description, the other showing the Charlier method of shoeing and the general anatomy of the foot; a full-sized model of the bones of the hind leg, giving shape, size and position of each individual bone; thirty-one full-sized models of the jaws and teeth of the horse and fourteen of the ox, showing the changes which take place in these organs as the animals advance in age.

There is an articulated skeleton of the famous stallion, Blackhawk, a disarticulated one of a thoroughbred mare, besides one each of the cow, sheep, pig and dog; two prepared dissections of the fore and hind legs of the horse, showing position and relation of the soft tissues to the bones; a *papier-maché* model of the uterus of the mare and of the pig; a gravid uterus of the cow; a wax model of the uterus, placenta and fœtus of the sheep, showing the position of the fœtus and the attachment of the placenta to the walls of the uterus.

In addition to the above there is a growing collection of pathological specimens of both the soft and osseus tissues, and many parasites common to the domestic animals. A collection of charts and diagrams especially prepared for the college is used in connection with lectures upon the subject of anatomy, parturition and conformation of animals.

Through the kindness of Mr. Henry Adams of Amherst the department has received a large sample collection of the various drugs used in the treatment of the diseases of the domestic animals.

For the benefit of the students, sick or diseased animals are frequently shown them, and operations performed in connection with the class-room work. For the use of the instructor of this department a laboratory has been provided in the old chapel building. It has been equipped with the apparatus necessary for the study of histology, pathology and bacteriology, consisting in part of an improved Zeiss microscope with a one-eighteenth inch objective, together with the lower powers; a Lautenschlager's incubator and hot-air sterilizer; an Arnold's steam sterilizer and a Bausch and Lomb improved laboratory microtome. This apparatus is used for the preparation of material for the class room and for general investigation.

Mathematical Department.

At first glance it might appear that mathematics would play a very small part in the curriculum of an agricultural college, and, while it is true that its chief object is of a supplementary nature, it is equally true that, entirely aside from its value as a means of mental discipline, mathematics has a well-defined and practical object to accomplish. In this day of scientific experiment, observation and research on the farm, the advantages of a thorough knowledge of the more elementary branches of mathematics, general physics and engineering must be more than ever apparent; and it is to meet the needs of the agricultural college student in these lines that the work in the mathematical department has been planned.

The mathematics of the freshman, sophomore and junior years are required, those of the senior year elective.

A glance at the schedule of studies will show the sequence of subjects: book-keeping, algebra, geometry and mechanical drawing in the freshman year; trigonometry, mechanical drawing and plane surveying — the latter embracing lectures and field work in elementary engineering, the use of instruments, computation of areas, levelling, etc. — in the sophomore year; general physics — including mechanics, electricity, sound, light and heat — and descriptive geometry or advanced mechanical drawing in the junior year; and, finally, two electives in the senior year, — mathematics and engineering respectively.*

The mathematical option includes the following subjects: fall term, plane analytic geometry, embracing a study of the equations and properties of the point, line and circle, and of the parabola, ellipse and hyperbola; winter term, differential calculus; and summer term, integral calculus.

The senior engineering option is designed to give to the student the necessary engineering training to enable him to take up and apply, on the lines of landscape engineering and the development of property, his knowledge of landscape gardening, agriculture, forestry, botany and horticulture. It embraces a course of lectures, recitations and field work on the following subjects: topography, railroad curves, earth work, construction and maintenance of roads, water works and sewerage systems, etc.

It is believed that the engineering elective will equip the student to enter a comparatively new field, that of landscape engineering, which is coming more and more prominently before the public attention; for, with the increasing consideration which is being paid to the public health and the development and beautifying of our towns and cities, come fresh needs and opportunities.

---

* While these two electives are entirely distinct, the student electing engineering is strongly advised to elect mathematics also.

CHEMICAL DEPARTMENT.

Instruction in general agricultural and analytical chemistry and mineralogy is given in the laboratory building. Thirteen commodious rooms, well lighted, ventilated and properly fitted, are occupied by the chemical department.

The lecture room, on the second floor, has ample seating capacity for seventy students. Immediately adjoining it are four smaller rooms, which serve for storing apparatus and preparing material for the lecture table.

The laboratory for beginners is a capacious room on the first floor. It is furnished with forty working tables. Each table is provided with sets of wet and dry re-agents, a fume chamber, water, gas, drawer and locker, and apparatus sufficient to render the student independent of carelessness or accident on the part of others working near by; thus equipped, each worker has the opportunity, under the direction of an instructor, of repeating the processes which he has previously studied in the lecture room, and of carrying out at will any tests which his own observation may suggest.

A systematic study of the properties of elementary matter is here taken up, then the study of the simpler combinations of the elements and their artificial preparation; then follows qualitative analysis of salts, minerals, soils, fertilizers, animal and vegetable products.

The laboratory for advanced students has tables for thirty workers, with adequate apparatus. This is for instruction in the chemistry of various manufacturing industries, especially those of agricultural interest, as the production of sugar, starch, fibres and dairy products; the preparation of plant and animal foods, their digestion, assimilation and economic use; the official analysis of fertilizers, fodders and foods; the analysis of soils and waters, of milk, urine and other animal and vegetable products.

The balance room has four balances and improved apparatus for determining densities of solids, liquids and gases.

Apparatus and Collections. — Large purchases of apparatus have recently been made. Deficiencies caused by the wear and breakage of several years have been supplied and the original outfit increased. The apparatus includes balances, a microscope, spectroscope, polariscope, photometer, barometer and numerous models and sets of apparatus. The various rooms are furnished with an extensive collection of industrial charts. A valuable and growing collection of specimens and samples, fitted to illustrate different subjects taught, is also provided. This includes rocks, minerals, soils, raw and manufactured fertilizers, foods, including milling products, fibres and other vegetable and animal products and artificial preparations of mineral and organic compounds. Series of preparations are used for illustrating the various stages of different manufactures from raw materials to finished products.

Library.

This now numbers 17,810 volumes, having been increased during the year, by gift and purchase, 730 volumes. It is placed in the lower hall of the chapel-library building, and is made available to the general student for reference or investigation. It is especially valuable as a library of reference, and no pains will be spared to make it complete in the departments of agriculture, horticulture, botany and the natural sciences. It is open a portion of each day for consultation, and an hour every evening for the drawing of books.

PRIZES.

Burnham Rhetorical Prizes.

These prizes are awarded for excellence in declamation, and are open to competition, under certain restrictions, to members of the sophomore and freshman classes.

Flint Prizes.

Mr. Charles L. Flint of the class of 1881 has established two prizes, one of thirty dollars and another of twenty dollars, to be awarded, at an appointed time during commencement week, to the two members of the junior class who may produce the best orations. Excellence in both composition and delivery is considered in making the award.

Grinnell Agricultural Prizes.

Hon. William Claflin of Boston has given the sum of one thousand dollars for the endowment of a first and second prize, to be called the Grinnell agricultural prizes, in honor of George B. Grinnell, Esq., of New York. These two prizes are to be paid in cash to those two members of the graduating class who may pass the best written and oral examination in theoretical and practical agriculture.

Hills Botanical Prizes.

For the best herbarium collected by a member of the class of 1897 fifteen dollars is offered, and for the second best a prize of ten dollars; also a prize of five dollars for the best collection of dried plants from the college farm.

The prizes in 1896 were awarded as follows: —

Burnham Rhetorical Prizes: John P. Nickerson (1898), first; Randall D. Warden (1898), second; Dan A. Beaman (1899), first; John R. Dutcher (1899), second.

Flint Oratorical Prizes: Charles I. Goessmann (1897), first; Lafayette F. Clark (1897), second; John A. Emrich (1897), most honorable mention.

Grinnell Agricultural Prizes: Harry H. Roper (1896), first; Henry W. Moore (1896), second.

Hills Botanical Prizes: James F. Hammar (1896), first; Lucius J. Shepard (1896), second.

Collection of Woods: Asa S. Kinney (1896).

Military Prizes: gold medal, presented by I. C. Greene, '94, Charles A. Peters (1897); military suit, presented by Alfred Glynn, Amherst, Alexander Montgomery, Jr. (1898).

Freshman Botanical Prize: Charles M. Walker (1899).

RELIGIOUS SERVICES.

Students are required to attend prayers every week-day at 8 A.M. and public worship in the chapel every Sunday at 10.30 A.M. Further opportunities for moral and religious culture are afforded by a Bible class taught by one of the professors during the hour preceding the Sunday morning service and by religious meetings held on Sunday afternoon and during the week, under the auspices of the College Young Men's Christian Association.

LOCATION.

Amherst is on the New London Northern Railroad, connecting at Palmer with the Boston & Albany Railroad, and at Miller's Falls with the Fitchburg Railroad. It is also on the Central Massachusetts Railroad, connecting at Northampton with the Connecticut River Railroad and with the New Haven & Northampton Railroad.

The college buildings are on a healthful site, commanding one of the finest views in New England. The large farm of three hundred and eighty-three acres, with its varied surface and native forests, gives the student the freedom and quiet of a country home.

REPORTS.

GIFTS.

From George R. Foulke of West Chester, Pa., Chester White boar.

The Barber Asphalt Paving Company of New York, cabinet containing an economic exhibit of asphalt and its compounds as used for asphalt paving, together with sundry views of asphalt streets, and a bibliography of the subject.

The Catskill Shale Brick and Paving Company, sample shale paving brick.

H. D. Graves of Sunderland, maple burl log.

George Cruickshanks of Fitchburg, natural graft, pine; also photograph of same.

L. R. Alexander (M. A. C., School of Agriculture, '96) of East Northfield, sassafras log, and collection of insects.

George Tsuda (M. A. C., '96) of Tokyo, Japan, collection of bamboos mounted and catalogued, with description.

S. Sastré (M. A. C., '96) of Tabasco, Mexico, collection of insects.

Philip H. Smith, Jr. (M. A. C., '97) of South Hadley Falls, collection of insects.

James Page of Amherst, peacock.

Charles I. Goessmann (M. A. C.,'97) of Amherst, collection of birds' eggs and nests.

Mrs. H. A. Holt of Amherst, collection of birds' eggs and nests.

Leach, Shewell & Sanborn of Boston, "Paradise Lost."

Andrew Carnegie of Pennsylvania, "Science of Nutrition and Art of Cooking in the Aladdin Oven."

Dr. Maercker of Germany, "Uber die Phosphorsaüre-wirkung des Knochenmehle."

Charles E. Beach (M. A. C., '82) of Hartford, Conn., "Reports of Connecticut Dairy Commissioner."

A. D. F. Hamlin of New York, "Text-book of the History of Architecture."

From H. N. Legate (M. A. C., '91) of Boston, "Report of Board of Metropolitan Park Commissioners."

Ferris Publishing Company of Albany, N. Y., one volume "Poultry Monthly."

Miss Eleanor A. Ormerod of Spring Grove, England, "Nineteenth Report of Observations on Injurious Insects."

Wm. H. Caldwell (M. A. C., '87) of Peterboro, N. H., "Guernsey Breeders' Year Book."

Hon. Richard W. Irwin of Northampton, six volumes State documents.

Newton Shultis (M. A. C., '96) of Medford, "Discovery and Conquest of the New World."

Charles P. Lounsbury (M. A. C., '94) of Cape Town, Africa, "An African Farm;" "Dreams;" "Handbook of Cape and South Africa;" "Report of Government Entomologist."

Joseph E. Pond, Esq., of North Attleborough, four volumes "Bee Journals."

Asa W. Dickinson (M. A. C., '74) of Jersey City, N. J., ten volumes "Works of Eugene Field."

His Highness the Maharajah of Jeypore, India, seven volumes "Jeypore Portfolio of Architectural Details."

Herbert S. Carruth (M. A. C., '75) of Ashmont, "Three Episodes of Massachusetts History;" "Memoirs of Robert Lee."

Hon. George F. Hoar of Worcester, six volumes government reports.

Charles S. Plumb (M. A. C., '82) of Lafayette, Ind., three volumes "Indiana Dairy Reports."

Vernon L. Kellogg, "New Mallophaga," two parts.

Wm. Trelease of St. Louis, Mo., "Sturtevant Prelinnæan Library of the Missouri Botanical Garden."

Hon. Frederick H. Gillette of Springfield, three volumes government documents.

Cyrus H. McCormick of Chicago, Ill., "Inventors."

J. H. Benton, "Public Libraries as a Means of Education."

Robert H. Smith (M. A. C., '92) of Amherst, "Beside the Bonnie Brier Bush;" "A Singular Life."

Frank A. Bates of Malden, "Game Birds of North America."

J. D. W. French of Boston, four volumes "Index Kewensis."

John R. Perry (M. A. C., '93) of Boston, "Primer of College Foot-ball."

Different college organizations, group pictures of the same.

TREASURER'S REPORT.

Report of George F. Mills, *Treasurer Massachusetts Agricultural College, from Jan. 1, 1896, to Jan. 1, 1897.*

	Received.	Paid.
Cash on hand Jan. 1, 1896,	$7,801 46	–
State treasurer,	14,666 66	–
Morrill fund,	–	$1,000 00
Term bill,	3,808 20	710 88
Horticultural department,	5,419 10	7,337 81
Farm,	5,683 18	9,439 66
Expense,	1,452 23	8,679 27
Salary,	250 00	27,145 76
Endowment fund,	11,185 02	–
State scholarship fund,	15,000 00	–
Chemical laboratory,	1,712 64	1,349 99
Botanical laboratory,	84 50	129 15
Entomological laboratory,	38 00	13 98
Zoölogical laboratory,	68 00	77 97
Labor fund,	5,000 00	4,562 02
Gassett scholarship fund,	65 00	30 00
Whiting Street fund,	56 90	135 00
Grinnell prize fund,	40 00	40 00
Mary Robinson fund,	35 84	25 00
Burnham emergency fund,	200 00	559 30
Hills fund,	356 16	209 55
Extra instruction,	–	437 50
Advertising,	–	661 34
Library fund,	404 59	404 59
Investment, N. Y. C. & H. R. R.R.,	4 00	–
Insurance,	11 25	1,198 15
Insurance, barn,	–	2,509 16
Insurance, vehicles, tools, etc.,	–	101 70
Electric plant,	730 88	2,075 75
Dairy equipment,	–	930 10
Cash on hand Jan. 1, 1897,	–	4,309 98
	$74,073 61	$74,073 61

This is to certify that I have this day examined the accounts of George F. Mills, treasurer Massachusetts Agricultural College, from Jan. 1, 1896, to Jan. 1, 1897, and find the same correct, properly kept, and all disbursements vouched for, the balance in the treasury being four thousand three hundred and nine and ninety-eight one-hundredths dollars ($4,309 98), which sum is shown to be in the hands of the treasurer.

CHARLES A. GLEASON, *Auditor.*

Amherst, Dec. 29, 1896.

Cash Balance, as shown by the Treasurer's Statement, belongs to the Following Accounts:

Gassett scholarship fund,	$61 02
Mary Robinson fund,	23 92
Grinnell prize fund,	20 00
Hills fund,	190 34
Labor fund,	717 42
General fund,	3,297 28
	$4,309 98

Bills receivable Jan. 1, 1897.

Term bill,	$931 18
Horticultural department,	346 89
Farm,	335 12
Expense,	79 64
Electric plant,	130 87
Chemical laboratory,	338 40
Botanical laboratory,	6 00
Zoölogical laboratory,	24 00
Entomological laboratory,	12 00
	$2,204 10

Bills payable Jan. 1, 1897.

Term bill,	$44 07
Horticultural department,	32 39
Farm,	3,227 54
Electric plant,	270 41
Expense,	1,239 58
Chemical laboratory,	257 19
Labor fund,	5 88
	$5,077 06

Inventory — real estate.

Land (Estimated Value).

College farm,	$37,000 00	
Pelham quarry,	500 00	
Bangs place,	1,750 00	
Clark place,	4,500 00	
		$43,750 00

Buildings (Estimated Value).

Drill hall,	$5,000 00	
Powder house,	75 00	
Gun shed,	1,500 00	
Stone chapel,	30,000 00	
South dormitory,	35,000 00	
North dormitory,	25,000 00	
Amounts carried forward,	$96,575 00	$43,750 00

Amounts brought forward,	$96,575 00	$43,750 00
Chemical laboratory,	8,000 00	
Entomological laboratory,	3,000 00	
Farm house,	2,000 00	
Horse barn,	5,000 00	
Farm barn and dairy school,	33,000 00	
Graves house and barn,	2,500 00	
Boarding-house,	2,000 00	
Botanic museum,	4,500 00	
Botanic barn,	2,500 00	
Tool house,	2,000 00	
Durfee plant house and fixtures,	12,000 00	
Small plant house, with vegetable cellar and cold grapery,	4,700 00	
President's house,	6,500 00	
Dwelling-houses, purchased with farm,	5,000 00	
		189,275 00
		$233,025 00

PERSONAL PROPERTY.

Electric plant,	$6,500 00
N. Y. C. & H. R. R.R. stock,	100 00
Botanical department,	3,610 00
Horticultural department,	7,218 13
Farm,	16,637 25
Chemical laboratory,	2,101 00
Botanical laboratory,	2,056 53
Zoölogical laboratory,	1,800 00
Natural history collection,	5,186 00
Veterinary department,	1,615 66
Physics and mathematics,	4,513 00
Agricultural department,	2,675 00
Dairy equipment,	900 00
Library,	17,810 00
Fire apparatus,	300 00
Furniture,	600 00
Books in treasurer's office,	250 21
	$73,872 78

SUMMARY.

Assets.

Total value of real estate, per inventory,	$233,025 00
Total value of personal property, per inventory,	73,872 78
Bills receivable,	2,204 10
	$309,101 88

Liabilities.

Bills payable,	5,077 06
	$304,024 82

MAINTENANCE FUNDS.

Technical educational fund, United States grant,	$219,000 00
Technical educational fund, State grant,	141,575 35
	$360,575 35

Two-thirds of the income from these funds is paid to the treasurer of the college and one-third to the Institute of Technology. Amount received by the college treasurer from Jan. 1, 1896, to Jan. 1, 1897,	$11,185 02
Morrill fund, in accordance with act of Congress, approved Aug. 30, 1890. Amount received in 1896,	14,666.66
Hills fund, the gift of Messrs. L. M. and H. F. Hills of Amherst, now amounts to $8,542. By conditions of the gift the income is used for the maintenance of a botanic garden. Income from Jan. 1, 1896, to Jan. 1, 1897,	356 16
Annual State appropriation, $10,000. This sum was appropriated for four years by the Legislature of 1889, continued for another four years by the Legislature of 1892, and again by the Legislature of 1896, for the endowment of additional chairs of instruction and for general expense. Five thousand dollars of this sum was set apart as a labor fund, to be used in payment of labor performed by needy and worthy students. Amount received from annual State appropriation for college expense from Jan. 1, 1896, to Jan. 1, 1897,	5,000 00
Amount received as labor fund	5,000 00

SCHOLARSHIP FUNDS.

State scholarship fund, $10,000. This sum was appropriated by the Legislature of 1896, and is paid to the college treasurer in quarterly payments. Amount received from Jan. 1, 1896, to Jan. 1, 1897,	10,000 00
Whiting Street fund, $1,000. This fund is a bequest without conditions. To it was added, by vote of the trustees in January, 1887, interest accrued on the bequest, $260. Amount of the fund Jan, 1, 1897, $1,260. Income from Jan. 1, 1896, to Jan. 1, 1897,	56 90
Gassett scholarship fund, $1,000. This sum was given as a scholarship by Hon. Henry Gassett. Income from Jan. 1, 1896, to Jan. 1, 1897,	65 00
Mary Robinson fund, $858. This fund was given without conditions. The income from it has been appropriated for scholarships to needy and worthy students. Income from Jan. 1, 1896, to Jan. 1, 1897,	35 84
Amount carried forward,	$46,365 58

Amount brought forward,	$46,365 58

Prize Funds.

Grinnell prize fund, $1,000. This fund is the gift of Ex-Gov. William Claflin, and is called Grinnell Fund in honor of his friend, George B. Grinnell, Esq. The income from it is appropriated for two prizes to be given to the two members of the graduating class who pass the best examination in agriculture. Income from Jan. 1, 1896, to Jan. 1, 1897,	40 00

Miscellaneous Funds.

Library fund for the benefit of the library. Amount of fund, Jan. 1, 1897, $9,825.06.	
Burnham emergency fund, $5,000. This fund is a bequest of Mr. T. O. H P. Burnham, late of Boston, and was made without conditions. The trustees have voted that this fund be kept intact, and that the income from it be used by the trustees for such purposes as they believe to be for the best interests of the college. Income from Jan. 1, 1896, to Jan. 1, 1897,	200 00
Income from Jan 1, 1896, to Jan. 1, 1897,	$46,605 58

To this sum should be added amount of tuition and room rent, and receipts from sales from farm and from botanic gardens. These amounts can be learned from treasurer's statement, tuition and room rent being included in term bill account.

REPORT OF THE PRESIDENT OF THE MASSACHUSETTS AGRICULTURAL COLLEGE TO THE SECRETARY OF AGRICULTURE AND THE SECRETARY OF THE INTERIOR, AS REQUIRED BY ACT OF CONGRESS OF AUG. 30, 1890, IN AID OF COLLEGES OF AGRICULTURE AND THE MECHANIC ARTS.

I. Condition and Progress of the Institution, Year ended June 30, 1896.

The college has continued to feel the effects of the hard times, and the attendance has fallen off in a marked degree during the year ending June 30, 1896. Aside from this, the year has been one of prosperity. The personnel of the faculty remains the same, but the course of study has been modified to meet the demands of the hour. It has been deemed unwise to longer carry on the two-years course and it has been discontinued. In its place eleven short winter courses have been substituted, all optional, all free to citizens of the State and all without limitation of entrance examination. These are arranged under the heads of general agriculture, animal husbandry, dairying, fruit culture, floriculture, market gardening, botany, chemistry, zoölogy. Three new elective courses have been offered in engineering, mathematics and advanced English.

Under appropriations from the State the following buildings have been erected: a laboratory, at a cost of $3,000, two stories high, thirty-two by thirty-six feet, containing stands and appliances adequate for instruction of eighteen to twenty students in economic entomology; a gun room, at a cost of $1,800, twenty-eight by sixty feet, providing shelter for the new breech-loading steel cannon issued by the war department, and a shooting gallery for practice during the winter months. In addition to the above, under legislative appropriation of $5,500, the college domain has been increased by the purchase of twenty acres for use in the horticultural department.

II. Receipts for and during the Year ended June 30, 1896.

1. Balance on hand July 1, 1895,	$578 96
2. State aid: (*a*) Income from endowment,	3,913 60
(*b*) Appropriations for building or other special purposes,	10,300 00
(*c*) Appropriation for current expenses,	15,000 00
Amount carried forward,	$29,792 56

Amount brought forward,	$29,792 56
3. Federal aid: (*a*) Income from land grant, act of July 2, 1862,	7,300 00
(*b*) For experiment stations, act of March 2, 1887,	15,000 00
(*c*) Additional endowment, act of Aug. 30, 1890,	14,000 00
4. Fees and all other sources,	1,000 00
Total receipts,	$67,092 56

III. *Expenditures for and during the Year ended June 30, 1896.*

1. College of Agriculture and Mechanic Arts,	$25,004 16
2. Experiment Station,	15,000 00
Total expenditures,	$40,004 16

IV. *Property and Equipment, Year ended June 30, 1896.*

Agricultural department: —	
Value of buildings,	$250,940 00
Value of other equipment,	$71,943 80
Total number of acres,	404
Acres under cultivation,	260
Acres used for experiments,	60
Value of farm lands,	$45,000 00
Amount of all endowment funds,	$360,575 35

V. *Faculty during the Year ended June 30, 1896.*

	Male.	Female.
1. College of Agriculture and Mechanic Arts, collegiate and special classes,	18	-
2. Number of staff of Experiment Station,	18	1
Total, counting none twice,	28	1

VI. *Students during the Year ended June 30, 1896.*

1. College of Agriculture and Mechanic Arts, collegiate and special classes,	161
2. Graduate courses,	15
Total, counting none twice,	176

VII. *Library, Year ended June 30, 1896.*

1 Number of bound volumes June 30, 1896,	*17,365
2. Bound volumes added during year ended June 30, 1896,	*982
Total bound volumes,	17,365

---

* Pamphlets, none.

FARM REPORT.

The farm operations of the past season have been conducted along the same general lines as for several years; the objects in view being the systematic improvement of the estate, the illustration of the best methods in performing all farm operations and in the management of live stock and dairy, and the carrying out of such experiments in all departments as may seem desirable.

"The meteorological conditions," reports the farm superintendent, Mr. Jones, "have, in the main, been favorable for the growth of the more important farm crops; yet the cold, dry weather of the early spring retarded the growth of the onion and root crops, and materially lessened the yield of hay on the upland mowings."

To this statement, I believe, should be added that the frequent rains and excessive heat of the latter part of the summer undoubtedly decreased the yield of sound onions, mangels and turnips, as not all parts of the land devoted to them are well drained.

The number of acres in the various crops was as follows: hay, 80; corn for the silo, 25⅓; potatoes, 8½; corn for husking, 5; millet, 4½; onions, 2¾; Swedes, 1¼; mangels, 1; carrots, 1; celery, 1; soya beans, 4; horse beans, 1; oats and vetches, 2; a total of 137⅓ acres.

The several fields and products were as follows: —

Hay. — Old fields (between college buildings and the county road), estimated, 30 acres: hay, 54 tons, 121 pounds; rowen, 11 tons; middle flat, 12 acres: hay, 21 tons, 160 pounds; rowen, 7 tons, 675 pounds; south flat, 32 acres: hay, 52 tons, 805 pounds; rowen, 26 tons, 565 pounds; Hatch slope, about 6 acres: hay, 13 tons, 1,030 pounds; rowen, 7 tons. This gives a total from about 80 acres of 194 tons and 556 pounds, or 2.43 tons per acre. The yield in one field of 5½ acres of timothy and the rowen crop in all the old fields was seriously decreased by the ravages of the army worm, which are alluded to later in this report somewhat more in detail.

Potatoes. — North of Target Butt, 8½ acres: merchantable tubers, 1,041 bushels; small tubers, 273 bushels.

Corn for the Silo. —Twenty-five and one-third acres: fodder weighed into the silo, 279 tons, 70 pounds.

Oats and Vetch Hay. — North flat, 2 acres: 5 tons, 1,000 pounds.

Japanese Barn-yard Millet. — North flat, 1 acre: 4 tons, 1,000 pounds hay.

Corn for Husking. — Sand knoll, three-quarters of an acre: grain, 46.8 bushels; stover, 2.25 tons; south flat, 4¼ acres: grain, 319 bushels; stover, 24.5 tons.

Carrots. — South flat, 1 acre: 14 tons, 145 pounds.

Mangels. — South flat, 1 acre: 11.2 tons.

Onions. — South flat, 2½ acres: sound onions, 282.6 bushels.

Barn-yard Millet. — Campus slope, 3 acres: 37.4 tons, weighed into the silo.

Soya Beans. — Campus slope, 4 acres: green fodder for silo, 41 tons, 620 pounds.

Horse Beans. — North flat, 1 acre: 5 tons, 1,541 pounds green fodder.

Celery. — North flat, 1 acre: 200 dozen bunches.

The prices of all farm products last year were so very low that the farm management found itself at the beginning of the past year upon so poor a financial basis that it was resolved to carry on the operations of this year almost entirely without commercial fertilizers. This seemed the more possible in view of the fact that the farm was once more very nearly fully stocked, and was therefore producing a large amount of manure. This manure was from the nature of the case in most instances applied fresh but a relatively short time before planting the crops, and was undoubtedly, therefore, not in condition to produce its full effect upon the crops of the past season. Then, too, the fact that the farm was so lightly stocked for the two years preceding the last has forced us to use less manure than usual in the recent past. These facts, together with the unfavorable effects of season due to imperfect drainage in some fields, account for a lower average in most staples than we have produced in recent years.

The system of manuring followed with the several crops is shown in the table: —

Application per Acre.

	Corn for Silo.	Corn for Husking.	Potatoes.	Soya Beans.	Japanese Barn-yard Millets.	Horse Beans.	Onions.	Swedes.	Mangels.	Carrots.	Celery.
Manure (cords),	4	4	–	4	4	6	9	–	6	10	6
Basic slag (pounds),	–	–	–	–	–	–	–	–	–	–	700
Bone meal (pounds),	–	–	–	–	–	–	–	–	–	–	800
Double sulphate potash and magnesia (pounds).	–	–	–	–	–	–	–	–	–	–	200
Dry ground fish (pounds),	–	–	–	–	–	–	–	–	–	–	300
Ashes (pounds),	–	–	–	–	–	–	2,000	–	–	–	–
Lime (pounds),	–	–	–	–	–	–	–	–	400	400	–
Coarse salt (pounds),	–	–	–	–	–	–	–	–	200	–	–

Corn for the Silo. — Our yield is the smallest average that we have ever produced, viz., but little over 11 tons. The unfavorable conditions other than the small application of manure and the lack of fertilizer already alluded to in a general way were the following: —

1. Poor seed, purchased from such source that it was believed to be undoubtedly good; and unwisely not tested because it looked bright.

2. The excessive use of town sewage on the field adjoining the college estate on the south, which renders several acres of the field where we produced most of our corn for the silo so wet that but little corn grew there.

3. A section of 2 acres from the middle of a field planted for husking on the south flat has not yet been drained; and the crop from this was so poor that it was cut and put into the silo, thus increasing the acreage of corn ensiled, but not much increasing the weight of product.

4. The old building site (barn and farmhouse) makes up 3½ acres of the total ensiled, and of course did not produce a full crop.

Japanese Barn-yard Millet. — Three acres on the campus slope, receiving at the rate of 4 cords per acre of barn-yard manure spread during the winter, gave a product of 37.4 tons, — rather more than 12 tons per acre. Analyses in previous years have shown this fodder to equal Indian corn in food value. The crop of this year has been put into the silo. It was sown broadcast, and of course received no culture.

Medium Green Soya Beans. — Four acres on the campus slope, manured as for the millet, were planted to this crop. The seed was planted with the Eclipse corn planter, about 12 to 15 seeds to the foot of row; rows 2½ feet apart. The growth was fine, and the crop cost but little labor to raise. The product was at the rate of 10.3 tons per acre. It was put into the silo in alternate layers with Indian corn, when the pods were filled but before the beans had hardened. It was put in in the proportion of one part of the beans to two parts of the corn. It is confidently anticipated that this will make a well-balanced silage.

Horse Bean. — One acre in good strong loam on the north flat was planted to this crop. It received an application of 6 cords of manure, spread after ploughing and harrowed in. The beans were planted in rows 1½ feet apart, 6 to 8 seeds to the foot, with a hand planter. The foliage blighted, and the yield (weighed as it was cut and fed green to the cows from day to day, being in bloom at the time) was only 5.8 tons. After two years' trial, I have decided that this crop is not likely to prove valuable with us.

New Implements. — The Robbins' potato planter was used in putting in our potatoes this year, with very great satisfaction. For its operation, a heavy pair of horses, a man and a boy are needed. It applies the fertilizer and plants the cut potatoes in an excellent manner. It is quite necessary that potatoes be cut evenly and rather small. The pieces are as a rule dropped with perfect regularity and all covered. This is not always the case with other planters. Three rows, planted, for the purpose of comparison, with the Aspinwall planter, showed many skips, and gave a product of 18 bushels; while the adjacent three rows, planted with the Robbins, showed hardly a skip, and gave a product of 37½ bushels. In justice to the Aspinwall planter, it should be stated that no effort was made to cover by hand the tubers not covered by the machine, and, further, that the pieces were perhaps rather too small for its best work. It was operated by one man, while the Robbins required also a boy. I do not attach great importance to the exact relations of the above figures giving yields, but I am fully convinced, as the result of a four years' trial, that we cannot in Massachusetts afford to use the Aspinwall planter, as under the best conditions there are too many failures to deposit and cover the seed.

Corn Harvester. — The farm superintendent, Mr. Jones, reports concerning the McCormick corn harvester as follows: "The entire crop of field and ensilage corn was cut this year with the McCormick corn harvester. The work was well done, and the method proved to be far more economical than hand labor. About six acres were found to be a fair average for a day's work. The corn, being bound in compact bundles, greatly facilitated the work of hauling and passing through the ensilage cutter."

Live Stock.

Horses. — Our horses and colts have been uniformly in a perfect condition of health throughout the year. We now own the following animals: Percherons, 1 stallion, 1 mare and 2 stallion colts; Percheron three-quarters blood, 1 stallion and 2 mare colts; one-half Percheron, 1 mare; ordinary work horses, 2 geldings and 2 mares; French coach, 1 stallion colt and 1 mare colt; total, 14.

Neat Cattle. — Shorthorn, 1 bull and 2 females; Guernsey, 2 bulls and 2 females; Jersey, 1 bull and 2 females; Ayrshire, 1 bull and 2 females; Holstein-Friesian, 1 bull and 2 cows; Aberdeen-Angus, 1 cow and 1 stag; Dakota cows, 34; Dakota heifers, 14; grade Hereford, 1 heifer; grade calves, 9; total, 76.

Southdown Sheep. — One breeding buck, 2 yearling bucks, 31 breeding ewes, 4 buck lambs and 4 ewe lambs; total, 42.

Swine. — Tamworth, 1 boar and 6 pigs; Chester White, 1 boar and 1 sow; Cheshire, 1 boar; Berkshire, 1 boar and 1 sow; Poland-China, 1 sow; total, 13.

The health of cattle and sheep has been good throughout the year, but there have been a few abortions among the cows, the cause of which is obscure. It is thought that it may be due to slipping upon the cement floor of the stable; but I do not feel at all confident that this is the case. The cattle were all retested with tuberculin during last winter, and not a case of tuberculosis was found. There has, indeed, been not the slightest evidence of this dread disease among our stock since we have occupied the new barn.

In restocking with swine we were so unfortunate as to get hog cholera with one of the animals; and as a result we lost by this disease a Chester White boar and a litter of twelve pigs, a Poland-China boar, a Cheshire sow, a Medium Yorkshire sow and six Tamworth sucking pigs. By isolation of infected animals and thorough disinfection we were able to check the disease within a short time, but not before it had seriously injured our stock. Not the least of the ill consequences is the failure to breed on the part of the animals that survived.

CASH RECEIPTS OF THE YEAR.

The total receipts of the year for products sold and for labor performed by farm teams and men amount to nearly $6,000. The leading items contributing to this total are the following: beef, $886.38; sheep and lambs, $95.45; dairy products, $1,790.10; hay, $561.72; potatoes, $264.26; onions, $81.75; celery, $112.48; corn, $15.15; wood, $802.26; stone, $92.25; ice, $122.47; work, $580.45.

SEEDING TO GRASS.

The method of seeding to grass in the standing corn has invariably given such satisfactory results that we have come to follow it almost to the entire exclusion of other methods. The seed is sown in showery weather the latter part of July, as a rule following immediately after the last cultivation. The men in sowing walk in every row, casting the seed three rows wide. The land is thus all sown over three times, and the result is very even distribution of the seed. This year the 17 acres on the campus slope were worked the last time (beginning July 25) with Breed's one-row weeder, and the seed sown immediately after. The mixture used per acre was as follows: —

	Pounds.
Timothy,	18
Red top,	8
Kentucky blue-grass,	5
Meadow fescue,	6
Mammoth red clover,	6
Alsike clover,	3

The seed came quickly and evenly, and the field promises a good crop another season.

The land which was occupied by the barn-yard millet and soya beans was ploughed after these crops were removed, and the land then sown with the mixture above given.

On the site of the old barn and farmhouse there were so many stones that it was thought better to remove the corn, plough and then sow. This was done, the following being the mixture of seeds used per acre: —

	Pounds.
Orchard grass,	20
Kentucky blue-grass,	4
Meadow fescue,	6
English rye-grass,	4
Tall oat grass,	6
Awnless brome grass,	4

Clover will be sown here in the spring.

RAPE AND WHITE MUSTARD.

At the last cultivation of the corn on the south flat, 4 acres were sown with Dwarf Essex rape at the rate of 2 pounds per acre, and 3 acres with white mustard, at the rate of 7 pounds per acre. Both crops came up evenly, but, probably on account of being shaded by the corn, did not make a large growth, and were not pastured. Both were ploughed under after the corn was removed.

PERMANENT IMPROVEMENTS.

The work of fitting the lot south of the Plainville road for pasture has been prosecuted as energetically as our resources would permit. The lot has been fenced in a substantial manner, our share of the lines amounting to a total length of 5,400 feet. We have put up a five-strand barbed wire fence with chestnut posts. Considerable work in clearing the lot of brush has also been done.

The grass seeds sown last summer and fall after burning the lot started well, and effectually smothered out the inferior natural grasses, sedges and weeds. The lot furnished a large share of the food needed during the summer by our herd of 40 cows.

A lane 84 rods long and 27 feet wide, leading from the barn to the pasture, has been fenced with Page's woven-wire fence, with chestnut posts. The style of fence employed is 56 inches high. It combines neatness, strength and durability in a remarkable degree, and has proved entirely satisfactory.

The remainder of the drive which led to the upper floor of our old barn has been carted away, about 200 loads of gravel having been taken out and applied to the college roads. Most of the stones which yet remained upon this old building site have also been picked up and carried away.

THE ARMY WORM.

Early in July we found a field of timothy seeded the previous August was seriously attacked by army worms, which before they were discovered had eaten a large share of the leaves and heads of the grass. A furrow as deep as could be turned with a heavy plough drawn by four horses was put around three sides of the piece, the fourth side being bounded by a brook. It so happened that the grass had been cut from a strip about one rod wide under the trees next the road on two sides, and the young grass here was powdered with Paris green, which application was, I believe, useless, as the worms when marching passed across without feeding.

At the same time the machines were started and the timothy was cut. This was in the forenoon. At about three o'clock in the afternoon the worms began to move out of the field in enormous numbers. They did not go into the brook, but poured into the furrows in countless myriads. Here they were checked, the side of the furrow farthest from the field having been cut as smooth as possible and with somewhat of a slope against the worms in their efforts to climb out of it. The furrow was not, however, a perfect barrier; many worms were found to be climbing out. Accordingly a line of coal tar was put in the bottom of the furrow round the three sides of the field. This was a great advantage. Many worms were killed by it; but the tar soon became filled with dead and dying worms, and in part soaked into the ground, and it was found that worms were again crossing. We then attacked them with pure kerosene oil, applied with a knapsack pump and spraying nozzle. We went over the furrow twice in this way that day, and found this method very effective. By this time it was dark, and the worms had mostly ceased moving.

The next day at about the same hour the movement of worms again began in even greater numbers than the first day. We again used tar and kerosene, and with equally satisfactory results.

Meanwhile the timothy had been cured and hauled to the barn, and the next morning before six o'clock we had applied Paris green to the entire six acres, using two Leggett's guns and putting on about three pounds of green to the acre. By noon of that day there were few worms in the field alive, and we had succeeded perfectly in keeping them out of adjoining fields of corn and grass, and literally annihilated the colony.

It was later found that there were some worms in other fields of grass which had been cut earlier, where they fed upon the new growth, preferring that of timothy and orchard grass. These worms caused a serious shortage in our rowen crop in all these fields. Where the worms were thick we applied some Paris green, which, as in the case of the larger field of timothy, was effective. There can be no danger in applying this poison soon after the main crop is removed, as in these cases, for it is sure to be all washed off before any rowen is ready to cut, if there are rains; and if there are no rains there will be no rowen.

It is a matter of grave uncertainty whether we shall be troubled with army worms next season. It is said they are seldom or never seriously troublesome two years in succession in the same place; but whether the past season is to be counted as *the serious one* we are unable to decide. The trouble was surely bad enough, but of course not nearly as serious as such incursions sometimes are. Burning the stubble in the spring is said to be useful in the case of threatened attacks of such worms.

In conclusion, I desire to testify to the efficient, faithful and skilful services of the farm superintendent, Mr. E. A. Jones, who brings to this important work in his alma mater unusual natural qualifications and an extended experience. To his careful management in my absence since August has been largely due such measure of success as has attended the farm operations.

WILLIAM P. BROOKS,
Professor of Agriculture.

HALLE A. S., GERMANY, Dec. 7, 1896.

MILITARY DEPARTMENT.

AMHERST, MASS., Dec. 31, 1896.

To President H. H. GOODELL, *Massachusetts Agricultural College.*

SIR: — I have the honor to submit my report of the military department of the college for the year ending Dec. 31, 1896.

In compliance with S. O., No. 173, H. Q. A., A. G. O., Washington, July 24, 1896, I relieved First Lieut. Walter M. Dickinson, Seventeenth Infantry, on the sixteenth of August last.

Drills commenced on September 3, and have been continued during the term on Monday, Tuesday and Thursday of each week. The command is organized in a battalion of three companies. A band has not been formed, owing to lack of talent; but it is hoped that a drum and trumpet corps or a drum and fife corps will be started early in January.

The companies have been instructed in all of the drill regulations up to battalion, but thus far there has not been opportunity for extended order drill, owing to lack of time. A very satisfactory state of efficiency has, however, been reached. Two companies were consolidated for platoon drill, each senior having an opportunity to drill it as captain and as chief of platoon. The seniors also received instruction in signalling with flag and heliograph, and with one or two exceptions are proficient.

All the companies received instruction in artillery and bayonet exercise, and during the latter part of the term considerable progress has been made in battalion drill.

There has been no target practice thus far, owing to the unsafe condition of the target pit and butt. Specifications for repairing the range, so that the markers will be able to work without danger to life or limb, will at an early date be submitted for your approval. Gallery practice and pointing and aiming drill will commence early in 1897.

The college dormitories are in excellent repair and condition, but I cannot recommend too strongly the placing of suitable water-closets, sinks and bath rooms in north college. I believe this to be the most urgent necessity that has come under my observation since joining here. The present system of janitors is not satisfactory, as the halls, sidewalks, sinks, water-closets, etc., are not kept in a proper state of police, although the responsible persons have been frequently spoken and written to about the matter. I recommend the employment of outside help for work of this character.

I concur most heartily with the recommendations of my predecessor regarding the transformation of the present gun shed into a combination gun shed and armory, and the use of the present armory for bath rooms, lavatories, lockers, etc., in connection with the gymnasium. I would also invite attention to the necessity of painting the outside of the drill hall.

The senior and freshman classes have received one hour theoretical instruction each week. The former have been instructed in drill regulations, including battalion drill, and in signalling with the flag and heliograph. The progress made was very satisfactory. The freshmen were instructed in drill regulations for one-half the time each week, the other half being taken up with a short lecture and discussion on some military subject, such as the Springfield rifle, the 3.2 inch B. L. rifle, infantry fire, customs of the service, articles of war, etc.

The discipline, *esprit* and attendance of the command are excellent, and are due in a great measure to the character of the work done by my predecessor and the unqualified and cordial support given this department by the college authorities.

The following three members of the last graduating class were reported to the Adjutant-General of the army and to the Adjutant-General of the State of Massachusetts as having shown the greatest proficiency in the art and science of war: —

Horace C. Burrington, ...	*Charlemont.*
Patrick A. Leamy, ...	*Petersham.*
Francis E. DeLuce, ...	*Warren.*

The following is a list of the United States property now on hand: —

Ordnance.

2 3.2-inch breech-loading steel guns.
2 8-inch mortars, with implements.
2 gun carriages.
2 gun caissons, with spare wheels.
2 mortar beds.
147 Springfield cadet rifles.
147 sets of infantry accoutrements.
51 headless shell extractors.
2,000 metallic ball cartridges.
2 mortar platforms.
2,000 pasters.
75 paper targets.
30,000 cartridge primers.
20,000 round balls.
1 set reloading tools.
75 pounds of small arms powder.
2 sets of implements and equipments for 3.2-inch breech-loading steel guns.

Signal.

2 heliographs, complete.
6 2-foot white flags.
6 2-foot red flags.
6 canvas cases and straps.
12 joints of staff.

The battalion organization is as follows: —

Commandant.

First Lieut. W. M. Wright,	Second U. S. Infantry.

Commissioned Staff.

Cadet First Lieutenant and Adjutant,	G. D. Leavens.
Cadet First Lieutenant and Quartermaster,	J. L. Bartlett.
Cadet First Lieutenant and Fire Marshal,	H. J. Armstrong.

Non-commissioned Staff.

Cadet Sergeant-Major,	A. Montgomery, Jr.
Cadet Quartermaster-Sergeant,	J. P. Nickerson.

Company A.

Cadet Captain,	J. M. Barry.
Cadet First Lieutenant,	C. I. Goessmann.
Cadet Second Lieutenant,	G. A. Drew.
Cadet First Sergeant,	L. L. Cheney.
Cadet Sergeant,	R. D. Warden.
Cadet Sergeant,	C. G. Clark.
Cadet Sergeant,	A. G. Adjemian.
Cadet Corporal,	E. M. Wright.
Cadet Corporal,	G. C. Hubbard.

Company B.

Cadet Captain,	J. A. Emrich.
Cadet First Lieutenant,	J. W. Allen.
Cadet Second Lieutenant,	H. F. Allen.
Cadet First Sergeant,	C. F. Palmer.
Cadet Sergeant,	W. S. Fisher.
Cadet Sergeant (Color Sergeant),	J. S. Eaton.
Cadet Corporal,	D. A. Beaman.
Cadet Corporal,	A. A. Boutelle.

Company C.

Cadet Captain,	P. H. Smith, Jr.
Cadet First Lieutenant,	C. A Peters.
Cadet Second Lieutenant,	C. A. Norton.
Cadet First Sergeant,	L. F. Clark.
Cadet Sergeant,	G. H. Wright.
Cadet Sergeant,	C. N. Baxter.
Cadet Corporal,	F. H. Turner.
Cadet Corporal,	J. R. Dutcher.

Respectfully submitted,

W. M. WRIGHT,
First Lieutenant Second Infantry.

THE SPRUCE GALL-LOUSE.

(*Chermes abietis* Linn.)

Prepared by Prof. Charles H. Fernald, Massachusetts Agricultural College.

The spruce gall-louse forms greenish galls on the twigs of various species of spruce, greatly injuring them and giving a very unsightly appearance to the trees. These galls (Plate II., Fig. 5) contain from three to thirty or more cavities, within each of which from ten to thirty of these minute yellowish insects may be found during the months of June and July, adhering to the walls of the cavities. About the middle of July the galls begin to dry, and the cavities opening allow the young gall-lice to escape. They crawl to the leaves, and after molting, their wings appear as shown in Fig. 10, Plate II. The body of the insect in this stage is brownish and the wings are transparent. The posterior end of the body, soon after molting the skin, is covered with a mass of fine white waxy hairs.

These insects soon come to rest on the leaves, and lay a cluster of small yellowish eggs, from twenty to fifty in number, each one being attached by a slender almost colorless thread (Plate II., figs. 4 and 6). The insect dies as soon as she lays her eggs, and her body serves as a protection to them.

The eggs hatch in about two weeks, and the exceedingly minute brownish insects crawl about over the twigs, some coming to rest on the leaves, others at the base of the buds. All of those on the leaves and many of those on the buds die before spring. Those which survive may be found early in May, enveloped in a dense coat of white waxy threads, which is quite conspicuous. These insects lay a large number of eggs which hatch in a few days, and the young, crawling to a gall, come to rest in the crevices and are soon enclosed by the enlarging gall. Here they remain till the opening of the gall allows them to escape, as described above.

PREDACEOUS ENEMIES.

The larva of the common lace-winged fly (*Chrysopa oculata* Say) has been taken feeding voraciously on the nymphs of this insect as they issued from the galls. This larva, also called the Aphis-lion, is a formidable-looking creature, measuring about a third of an inch from the tips of the long, sickle-shaped jaws with which it grasps its prey to the end of the abdomen. When fully grown the larva spins a nearly spherical white cocoon, from which, after about two weeks, the adult insect, with a slender green body and large delicate-veined wings, emerges.

W. R. Fisher, in his "Forest Protection" (Vol. VI. of Schlich's "Manual of Forestry," page 327), gives as a remedial measure the protection of the smaller insectivorous birds, as tits, the nut-hatch and golden-crested wren. He also states that a spider is an active destroyer of this insect, spinning its web over the galls and preventing the escape of its inmates.

REMEDIES.

Kerosene emulsion is the popular remedy for plant lice in general, and has been recommended by some for the spruce gall-louse; but it has been given a thorough test here, and failed to destroy the insect. Other experimenters have also been unable to destroy it with kerosene emulsion. Experiments were made with whale-oil soap on spruces growing near the insectary in Amherst. One pound of soap was dissolved in two gallons of water, and the infested trees were sprayed with this solution in April. This proved very effectual, as no insects have since been found on the trees thus treated.

A simple way of holding the insect in check, when not abundant, is to cut off the galls and burn them in the month of June, before the insects leave the cavities.

The following more technical account has been prepared by my assistant, Mr. R. A. Cooley, who has very patiently and successfully worked out the life history of this insect, and made all the studies and experiments on it, under my direction. No attempt has been made to give its foreign history nor references to foreign literature.

I am under obligations to Prof. L. O. Howard for valuable information on the distribution of the insect in this country.

THE SPRUCE GALL-LOUSE.

.(*Chermes abietis* Linn.)

The spruce gall-louse, also known as spruce bud-louse, spruce Adelges and spruce Chermes, like many other of our destructive insects, is a native of the old world, and was probably introduced into this country from northern Europe on Norway spruces. The exact date of introduction is not known, but the first mention of it in the United States that I have been able to find is in an article by Dr. Cyrus Thomas, in the "Transactions of the Illinois Horticultural Society" for the year 1876 (page 198). Dr. Thomas described the species provisionally as *Chermes abieticolens* in his third annual report (page 156, 1879). Dr. Packard had previously given a brief description of a species of Adelges occurring in abundance on the spruce in Maine, in his "Guide to the Study of Insects" (page 522), the first edition of which was published in 1869.

In order to learn the distribution of the species in this country, as well as to obtain other information, about five hundred circular letters were sent out to different persons in the United States and Canada. This resulted in the receipt of a large amount of desirable material and information. Only one species of Chermes was received, and the question at once arose whether it was *abietis* or *abieticolens*, as both species were said to be present in the United States. To settle this question, specimens in all stages were sent to Dr. N. A. Cholodkowski, professor of zoölogy in the Forst-Akademie in St. Petersburg, Russia, one of the most eminent authorities on this group of insects, and he determined it to be *Chermes abietis* Linn. From all the material and facts obtained there can be no doubt that *Adelges abieticolens* Thos., no types of which have been preserved, is identical with *Chermes abietis* Linn.

Distribution.

Chermes abietis is widely distributed in the United States, reaching from the Atlantic to the Pacific, but is chiefly confined to the transitional zone, though it has been received in a few instances from the northern edge of the upper austral zone. From what I have been able to learn through correspondence, it appears that the insect is far more common and destructive in New England than elsewhere in the United States. Outside of New England it has been received from Sing Sing, N. Y.; West Park, N. Y.;

Ridgewood, N. J.; State College, Pa.; Toronto, Can.; Denver, Col.; Fort Collins, Col.; Grand Rapids, Mich.; Chicago, Ill., and New Whatcome, Wash.; and it is also said to occur in Oregon. Hon. J. R. Anderson, deputy minister of agriculture, Victoria, British Columbia, wrote to Professor Fernald Oct. 5, 1896, that, after making particular inquiries from the correspondents of his department and from personal observations during his journeys through the country, he was of the opinion that this insect did not occur in British Columbia. He further wrote that he was informed that this or a similar pest was prevalent in the adjoining American States of Washington and Oregon, and that he feared it was only a question of time when it would find its way into British Columbia.

The Species in the Old World.

Buckton, in his "Monograph of the British Aphides" (Vol. IV., page 30), says: "This insect is numerous in many English counties. It also has a wide continental distribution, reaching as far south as Parma in Italy."

Destructiveness.

We have no record that these insects ever kill the trees, but they so generally disfigure them as to make them useless as ornaments or unsalable as nursery stock.

Mr. James Draper, proprietor of the Bloomingdale nurseries at Worcester, Mass., to whom we are indebted for courteous assistance in our study of the species, gave us the following information: "These little burrs made their appearance some three or four years ago and have been increasing some each year, so that I took hold of them in earnest the past year, and dug them out root and branch and burned them. There must have been a hundred trees at least, from six to eight feet in height, that we thus destroyed."

Other reports of the injuries of this insect have been received from different parts of the country. That the insect attacks forest spruces is shown by the following extract from a letter from Prof. C. P. Gillette, Fort Collins, Col., who very kindly sent us specimens from his locality: "This gall, which I send you, along with many others was taken near the timber line on Long's Peak, this State, early in August, by myself. Between 8,000 and 11,000 feet altitude the galls were common, but were most abundant near the timber line, where nearly every twig of Engleman's spruce was terminated by one. The galls were almost entirely green in color, or more or less rosy. Even the small trailing trees, at the very border of the timber, had hundreds of these galls upon them. I have not seen any of these galls or spruces growing outside the mountains." Numerous other statements of a similar nature have been received, which show that this insect is a serious pest.

Life History and Habits.

At the time the spruces are putting forth new shoots, about the second week of May in this locality, the eggs of this insect, together with the shrivelled body of the dead or dying female, may be found at the base of the buds, enveloped in a white woolly mass, about 3 mm. (one-eighth of an inch) in length. Each cluster contains about three hundred eggs, which are of a light yellow color and .4 mm. (nearly one-sixtieth of an inch) in length, each egg being attached by a very slender transparent stem about twice as long as the greatest diameter of the egg (Plate I., Fig. 9). In about one week these eggs hatch, and the minute nymphs, after remaining in the woolly mass for a few hours, venture out, and, crawling to the young and tender shoots, nestle closely in the cracks at the base of the leaves of the young galls which have already begun to form before their arrival. A very young shoot broken out from the bud scales before any of the eggs have hatched shows the basal leaves on the side where the female passed the winter, distinctly swollen at the base. The starting of the gall must therefore be attributed to the female rather than to the nymphs. It is reasonable to suppose, however, that the nymphs settling in the partially formed gall have some influence on its further development. In the young gall there is nothing to indicate that there will ever be cavities to enclose the nymphs, but as the gall develops it grows over the insects, the cavities gradually close, leaving only a semicircular incision, surrounded by grayish or pinkish pubescence. Young nymphs arriving later sometimes find it difficult to discover a cavity open enough to allow admission. In general, all the nymphs which enter one gall arise from the egg-cluster laid by one female. After the cavity has closed, the space within enlarges, and in a few days the young may be seen closely adhering to the sides, with their heads directed toward the opening.

The young nymphs are oval in form and flattened, .4 mm. (nearly one-sixtieth of an inch) in length, and of a light yellow color, with the legs, antennæ and proboscis slightly darkened. The eyes are black, and the antennæ, which are about as long as the lateral diameter of the head, consist of three segments, the first and second of which are nearly equal, while the third is regularly ringed and longer than the first two combined. The tarsus has but one segment, from which arises a pair of digitules near the outer end. The first molt occurs when the nymph is about two weeks old, and the molted skin is left attached to the tip of the abdomen. The next two molted skins are pushed off similarly, with the previous skin still attached, leaving three empty skins trailing from the end of the body. By this time all have become crowded and the skins are brushed off, and these, together with globules of liquid matter voided by the nymphs, make a considerable amount of debris. Sometimes a single molted skin at the end of the abdomen becomes distended with these liquid globules and strongly resembles a young nymph, and may sometimes have been mistaken for one.

I have been unable to determine the exact number of molts, but the foregoing facts would indicate that there are at least three before the insect reaches the adult stage.

The full-grown nymph (Plate II., figs. 1 and 2) is 2 mm. (about one-twelfth of an inch) long and 1 mm. wide, with the head, thorax and abdomen not distinctly separated. The head and thorax, together with all appendages, are yellow, but the abdomen is slightly more reddish. The wing pads are tinged with green in the majority of individuals, but in some they are light brown. The whole surface of the body is scantily covered with a white powdery secretion. The head is slightly bi-lobed; eyes large, black and conspicuous (mounts in Canada balsam show the eyes red). No ocelli are present. The antennæ are remote at the base, and have three segments, the third being much the longest. The legs have a protuberance at the end of the tibia, on the inside, on which the insect rests when walking. Abdomen distinctly segmented.

In the early part of August the nymphs have become full grown, and the galls begin to lose their dark-green color and slowly take on a yellowish tinge. The cavities slowly open, and the nymphs crawl out one by one, molt their skins, leaving them attached to the leaves, and crawl on, the wings developing as they go, half an hour being required for them to become fully expanded. The first winged specimens were observed at Amherst August 10. Most of the adults emerged before the 20th, but stragglers continued to appear for some time after. The galls turn from yellowish green to brown as they dry up, and before fall it is difficult to distinguish them from those produced in previous years. The younger and smaller nymphs left in the galls are forced to leave, and, crawling to the leaves, molt, producing under-sized adults.

If for any reason the gall dries up before the usual time, the nymphs appear to be able to transform to the winged individuals prematurely. I have one specimen, dated June 15, which emerged from a nymph bred from a gall on a twig in a bottle of water.

Winged female (Plate II., Fig. 10). — Length from face to tip of closed wings, 2.5 to 3 mm. (from one-eighth to one-tenth of an inch). Greatest width of body, 1 mm. Expanse of wings, 5.5 mm. (about one-fifth of an inch). Head broader than long, not separated from the thorax by a neck, very dark brown above, smoky yellow beneath. Eyes large and black, visible from below and above; ocelli three, one above each eye and one between the bases of the antennæ. Antennæ slightly longer than the width of the head, remote at the base, almost naked, and composed of five segments, of which segment two is the shortest, the others being subequal in length; segments one and two of greater diameter than those succeeding; segments three, four and five irregularly ringed, and having each a raised and smoothed surface near the outer end on the under side. Attachment between segments two and three slender. Prothorax broad and smoky yellow. Between the bases of the fore wings on the top of the thorax are four oval, very dark-brown spots, the outer being the largest; and there are three transverse, white waxy stripes, two in a line and one behind them. Sternal plate dark brown in color. Wings (Plate II., Fig. 8) four in number, the fore wings having the stigma and costal cell distinctly green, the stigma being darker green than the costal cell. There are two discoidal and one stigmatic vein. Hind wings with one more or less distinct oblique vein. The hooklets on the anterior margin are four in number, long and slender. Mouth parts somewhat sunken into the body at the base, extending a little past the anterior edge of the sternal plate. Legs of nearly equal length, spinose, especially on the inner side of the tibiæ. Abdomen lighter in color than the head and thorax, with the posterior end covered with a white flocculent secretion, which extends up the sides of the abdomen toward the thorax.

Newly emerged specimens are of nearly uniform yellowish color, but with age the darker markings become apparent, and later, the head and thorax become a nearly uniform deep brown, while the abdomen retains its yellowish color.

About two days after the female emerges as a perfect insect she begins laying her eggs, having first permanently attached herself to a leaf, generally near the tip, and inserted her mouth parts. Here she stays for the remainder of her life, her dead body serving as a protection for the egg-cluster which she deposits (Plate II., Fig. 4, shows an egg-cluster). The number of eggs varies widely, but is generally about forty, never much exceeding fifty, and the process of egg laying occupies about three days. As this process goes on the abdomen becomes much shortened, until finally the space which it occupied is largely filled by the egg-cluster.

Each egg is attached to the leaf by a slender stem of about the same length as the longest diameter of the egg (Plate II., Fig. 6). The whole mass is more or less covered with the flocculent secretion from the female.

An individual egg (Plate II., Fig. 6) is ellipsoidal in form, .4 mm. (about one-sixtieth of an inch) in length and half as wide. When it is laid it is light yellow, but before hatching it gradually turns darker. When the development of the young is well advanced, two black dots, the eyes of the embryo, may be distinctly seen opposite the end where the egg is attached. The eggs are laid in succession, and consequently do not all hatch at the same time, a period of about two weeks being required. The young nymphs remain under the body of the mother for a short time before coming out.

The insects of the winter generation are quite different from those of the summer generation, the adult form of which is winged. These may be called the young of the wingless female (Plate I., figs. 1 and 2). Soon after hatching they measure .4 mm. (about one-sixtieth of an inch) in length, and are oval, tapering slightly toward the posterior end. The top of the head and thorax and spots on the top of the abdomen are brown, the remainder of the body is yellowish brown. The body is distinctly annulated. The dorsum of the body is provided with numerous groups of pores, of from two to five openings each (Plate I., Fig. 3). The head and prothorax bear each six of these groups on each side; the five segments next following, three; the sixth, two; and the seventh segment, one on each side. Eyes small, black, situated on the sides of the head at the base. The eyes are afterward molted, so that the adult female is blind. The antennæ consist of three segments, of which the first two are of nearly equal length, while the third is much longer and irregularly ringed. The tarsus consists of a single segment, and is ringed similar to the terminal segment of the antennæ and provided with digitules. The sucking mouth parts are large and prominent. The setæ, four in number, are very long, and are disposed of by being doubled on themselves and coiled up in the body, only the part in use being protruded. The bristles may be protruded but a very short distance, or they may be extended five times the length of the body. I have watched an insect under a microscope, with these setæ nearly fully extended, slowly draw them back till all but the very tips disappeared within the body.

After hatching, the young females spread over the limb near by, some attaching themselves to the leaves and some crawling into the crevices at the axils of the leaves and at the base of the buds (Plate I., Fig. 10). None except those at the base of the buds survive the winter, and many thus protected are found dead in the spring. At first the insects are almost invisible, because of their small size, but as winter approaches they secrete from the pores in the back a coating of coarse white threads, which renders them more easily recognized. Before this time, however, all except those at the base of the buds have died and been brushed off.

On coming to rest, the young insect inserts its mouth parts and begins feeding, its size being increased but very little before cold weather sets in and stops its growth. In the spring the old winter coat is molted, and in its place the insect secretes another one of much finer texture. This is explained by the fact that before this molt the groups of pores contained only from two to five openings each, while after molting there are a great many openings. This molt occurs about the third week in April, after which the insect increases in size very rapidly, and secretes a more copious woolly coating. The first eggs were observed May 9. The female, having laid, soon dies, but the woolly mass clings long after the eggs have hatched, even remaining on the tree when the galls have dried up in the autumn.

The Male and Parthenogenesis.

The question whether any male of *Chermes abietis* exists, and, if it does, what it is like, has long been a subject of interest to entomologists. If there is no male, it follows that the females must produce young parthenogenetically; that is, without being fertilized by the male.

Buckton, in his "British Aphides" (Vol. IV., page 31), states that after searching the contents of a number of pseudo-cones he found "a single minute apterous insect, which proved to be the sex long missing." This he describes as measuring 0.030 by 0.015 mm., yellow, blind, apterous; antennæ rudimentary, three-jointed. Rostrum very short. Head broad and joined to the body without the intervention of any well-marked thorax. Abdomen large and deeply ringed. The posterior end is occupied by a remarkably developed male apparatus, which by compression under weak glycerine gives rise to a plentiful stream of spermatozoa.

Ratzeburg, in the third volume of his "Forst Insecten" (page 200), describes and figures (Plate XII.) what he believed to be a winged male.

During the two years that I have had this insect under observation I have examined a very large number of individuals, and have never found a male of any description. Yet I will not state, with Leuckart, that there is no male. It should be borne in mind that in some of the lower Homopterous insects the male is found with the female in some localities, while in others the females exist and reproduce without males (parthenogenetically).

As to the form described by Buckton as the male of this species, may it not be that it was a molted skin, distended by the liquid secretions of the nymph, as described in a previous paragraph of this paper?

Prof. N. A. Cholodkowski of St. Petersburg, who has been studying this and other species of the genus for several years, states, in the "Zoölogischer Anzeiger" for January, 1896 (page 37), that "*Chermes abietis* is therefore without doubt a clearly parthenoegnetic species." This conclusion he bases chiefly on the fact that *Chermes abietis* completes its life cycle in a single year, and therefore lacks the generation of males and females which in other species of the genus appear in the second year of the cycle.

In further consideration of this question, I would say that to determine this point I took a number of fully developed nymphs and placed one each on a small branch of spruce and enclosed them separately in small cages in the insectary, thus keeping them from all possible contact with males. These nymphs molted to winged imagoes, which laid eggs as usual, and these eggs hatched in due season.

Species of Spruce attacked.

Chermes abietis has been taken on the following species of spruce: white spruce (*Picea alba*), black spruce (*Picea nigra*), Norway spruce (*Picea excelsa*), hemlock spruce (*Picea canadensis*) and blue spruce (*Picea pungeus*). Small trees in nurseries and trees recently transplanted, or trees otherwise weakened by frost or animals, are more frequently attacked than others.

Physiological Botany of the Gall.

The fact that this insect by its own operations is able to cause a young twig to develop into such an abnormal form is very interesting. Physiological botany teaches that all such growths as galls caused by insects, and callouses which grow over wounds inflicted on trees, are the result of what is known as stimulation. The stimulation or irritation in this case is the puncture of the setæ of the hibernating female into the bud, as previously described. Botanists agree that stimulation of this nature sets up a division of the plant cells. Each cell divides in the middle, producing two, which after reaching full size divide as did the parent cell, thus producing four. As this goes on, a swelling is naturally produced, and this swelling is the gall. It is not necessary that the insect should sting or poison the plant; the piercing of the setæ is sufficient cause for the formation of the gall. Essentially the same thing occurs when the limb of a tree is sawed off. The inner bark, the growing part of the tree, is injured or stimulated, and the cell division begins, causing a swelling or callous, which gradually grows over the end of the limb. Why the gall should take on its characteristic form and color has not been explained.

As a result of the stimulation, there may be in addition to the cell divisions a deposition of material in the cells, as starch, proteids, resin, etc., which appear as minute granules of definite character. The plant cells of the gall produced by the insect are abnormally large, with thin walls, and contain more starch than those of the unaffected parts of the same stem. It may be that this starch is the food on which the young lice subsist.

Explanation of Plate I.

DRAWN BY R. A. COOLEY.

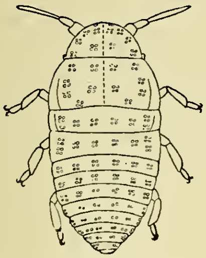
1. Top view of young female of the winter generation, enlarged.
2. Under view of same, enlarged.
3. A group of pores from the back of the young female of the winter generation, greatly enlarged.
4. End of the mouth parts of female of the winter generation, greatly enlarged.
5. Leg of the young female of the winter generation, greatly enlarged.
6. Top view of the denuded body of the adult female of the winter generation, enlarged.
7. Antenna of the adult female of the winter generation, greatly enlarged.
8. Mouth parts of the adult insect of the summer generation, showing the origin of the four setæ in the buccal cavity, greatly enlarged. Broken lines are internal, full lines are external.
9. An egg laid by the female of the winter generation, greatly enlarged.
10. Section of a spruce twig, showing the insects of the winter generation as they are in the fall, slightly enlarged.

Explanation of Plate II.

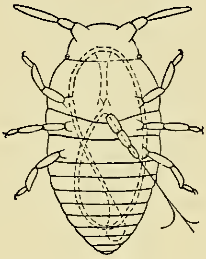
DRAWN BY R. A. COOLEY.

1. Top view of the nymph of the summer generation, enlarged.
2. Under view of the same, enlarged.
3. Antenna of nymph of the summer generation, greatly enlarged.
4. A cluster of eggs on a spruce needle, laid by the female of the summer generation, enlarged.
5. A spruce twig, with a vacated gall at the base.
6. An egg laid by the female of the summer generation, greatly enlarged.
7. Antenna of the adult female of the summer generation, greatly enlarged.
8. Fore and hind wing of female of the summer generation, enlarged.
9. Hooklets from the costa of the hind wing, in figure 8, greatly enlarged.
10. Top view of the adult female of the summer generation, enlarged.

Plate I.

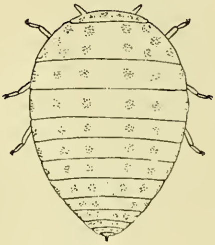

1

3

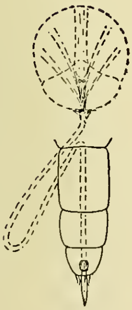

2

4

5


6

7


8

9

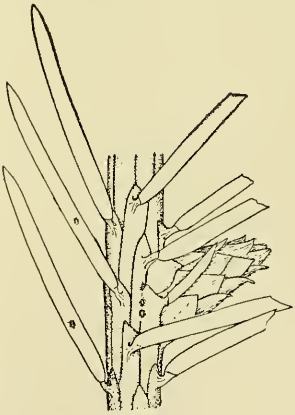
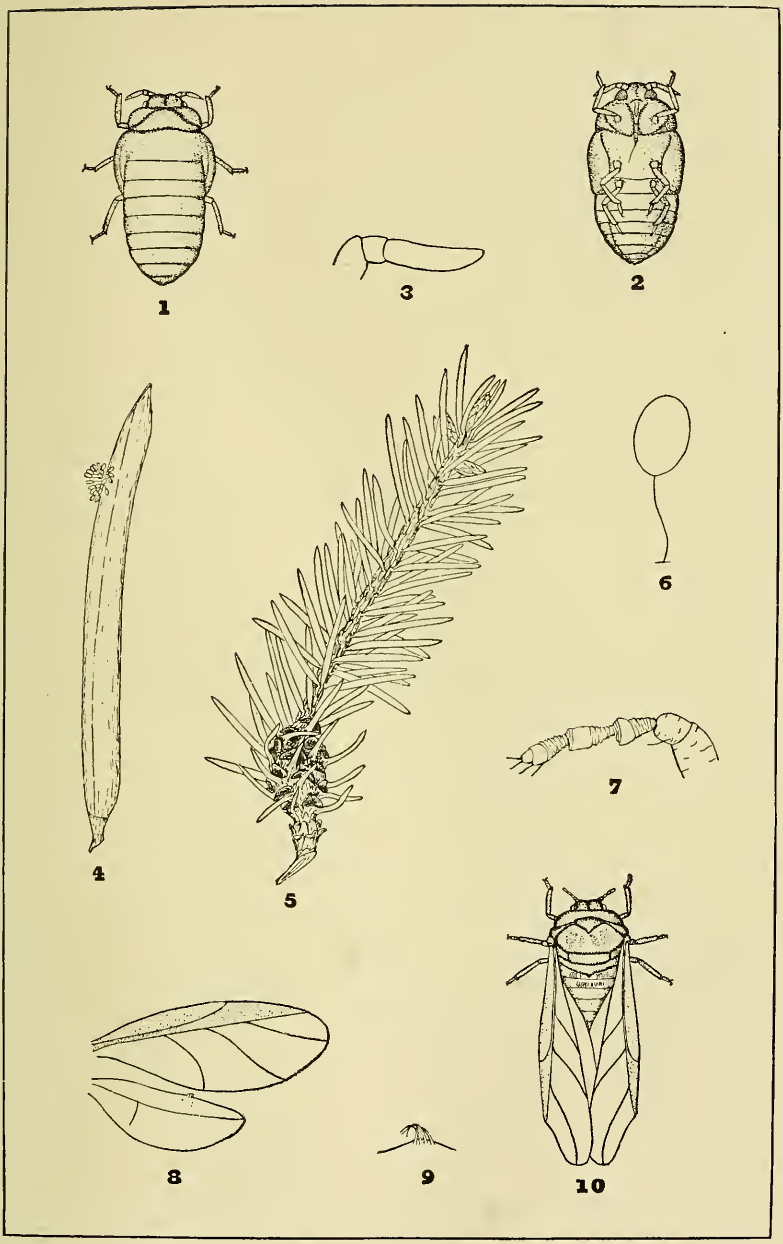

10

Plate II.



NINTH ANNUAL REPORT

OF THE

HATCH EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE.

JANUARY, 1897.

HATCH EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE,

AMHERST, MASS.

By act of the General Court, the Hatch Experiment Station and the State Experiment Station have been consolidated, under the name of the Hatch Experiment Station of the Massachusetts Agricultural College. Several new divisions have been created and the scope of others has been enlarged. To the horticultural has been added the duty of testing varieties of vegetables and seeds. The chemical has been divided, and a new division, "Foods and Feeding," has been established. The botanical, including plant physiology and disease, has been restored after temporary suspension.

The officers are: —

Henry H. Goodell, LL.D.,	*Director.*
William P. Brooks, B.Sc.,	*Agriculturist.*
George E. Stone, Ph.D.,	*Botanist.*
Charles A. Goessmann, Ph.D., LLD.,	*Chemist* (fertilizers).
Joseph B. Lindsey, Ph.D.,	*Chemist* (foods and feeding).
Charles H. Fernald, Ph.D.,	*Entomologist.*
Samuel T. Maynard, B.Sc.,	*Horticulturist.*
Leonard Metcalf, B.S.,	*Meteorologist.*
Henry M. Thomson, B.Sc.,	*Assistant Agriculturist.*
Ralph E. Smith, B.Sc.,	*Assistant Botanist.*
Henri D. Haskins, B.Sc.,	*Assistant Chemist* (fertilizers).
Robert H. Smith, B.Sc.,	*Assistant Chemist* (fertilizers).
Edward B. Holland, B.Sc.,	*Assistant Chemist* (foods and feeding).
Robert A. Cooley, B.Sc.,	*Assistant Entomologist.*
Joseph H. Putnam, B.Sc,	*Assistant Horticulturist.*
Benjamin K. Jones, B.Sc.,	*Assistant in Foods and Feeding.*

The co-operation and assistance of farmers, fruit growers, horticulturists and all interested, directly or indirectly, in agriculture, are earnestly requested. Communications may be addressed to the "Hatch Experiment Station, Amherst, Mass"

Bulletins issued, 1887–97.

No. 1. Protection of peach buds; effect of girdling; jumping sumac beetle.

No. 2. Grape-vine leaf hoppers; ants; poisonous doses of insecticides, and treatment; report on standard varieties of fruit.

No. 3. Bovine tuberculosis.

No. 4. Steam heat *v.* hot water for heating greenhouses; evaporated sulphur as an insecticide; plant diseases.

No. 5. Buffalo carpet beetle; larder beetle; clothes moth.

No. 6. Steam *v.* hot water; fungous diseases of plants.

No. 7. Tests of small fruits and vegetables; girdling; protection of fruit trees from animals; Japanese millets and beans; the gypsy moth.

No. 8. Steam *v.* hot water; peach yellows; danger from the use of milk coming from tuberculous cows.

No. 9. Soil tests.

No. 10. Special fertilizers for greenhouse crops; report on small fruits.

No. 11. Strength of rennet; hay caps; potato rot; fungicides and insecticides for fruit.

No. 12. Bud moth; spittle insects; squash bug; pea and bean weevil; May beetle; curculio; onion maggot; cabbage butterfly; tent caterpillar; forest tent caterpillar; stalk borer; pyramidal grape-vine caterpillar; grape-berry moth; codling moth; cabbage-leaf miner; gartered plume moth.

No. 13. Directions for using fungicides and insecticides.

No. 14. Fertilizers for corn.

No. 15. Over-bench *v.* under-bench heating; special fertilizers for plants under glass; varieties of strawberries, blackberries, raspberries.

No. 16. Summary of results in electro-culture.

No. 17. Fungicides and insecticides; varieties of grapes and peaches; protection of peach buds; copper on sprayed fruit; Siberian crab as a stock; girdling grape vines; spraying apparatus.

No. 18. Fertilizers for potatoes, oats and corn; muriate of potash; corn and millet as grain crops; report on oats, hemp, flax, English wheats, Japanese millets and beans.

No. 19. Gypsy moth; effect of Paris green on foliage; Barnard's insect trap; lice and spiders on rose bushes; kerosene emulsion; effects of Paris green on tent caterpillars; cranberry insects.

No. 20. Canker worms; tent caterpillar; fall web worm; tussock moths.

No. 21. Bordeaux mixture; ammoniacal carbonate of ammonia; copper sulphate; fruits.

No. 22. Small fruits.

No. 23. Electro-culture.

No. 24. Arsenate of lead; Paris green and lime; Jamestown weed; horn fly.

No. 25. Fungicides and insecticides; grape tests.

No. 26. Strawberries; blackberries; raspberries.

No. 27. Tuberculosis in college herd; tuberculin in diagnosis; bovine rabies; poisoning by nitrate of soda.

No. 28. Canker, army and corn worms; red-humped apple-tree caterpillar; antiopa butterfly; currant stem girdler; imported elm-bark louse; greenhouse orthezia.

No. 29. Fungicides and insecticides; new spraying pump; spraying calendar.

No. 30. Fertilizer analyses.

No. 31. Fertilizer analyses.

No. 32. Fertilizer analyses.

No. 33. Glossary of fodder terms.

No. 34. Fertilizer analyses; analyses of manurial substances.

No. 35. Agricultural value of bone meal.

No. 36. Imported elm-leaf beetle; maple pseudococcus; abbot sphinx; San José scale.

No. 37. Report on fruits, insecticides and fungicides.

No. 38. Fertilizer analyses; composition of Paris green; action of muriate of potash on the lime resources of the soil.

No. 39. Economic feeding of milch cows.

No. 40. Fertilizer analyses.

No. 41. On the use of tuberculin (translated from Dr. Bang).

No. 42. Fertilizer analyses; fertilizer laws.

No. 43. Effects of electricity on germination of seeds.

Special Bulletins.

Index, 1888 to 1895.
Gypsy moth.
The most profitable use of commercial fertilizers (translated from Paul Wagner).
The true value of green manuring (translated from Julius Kuehn).

Of the above bulletins, the edition of No. 2 is entirely exhausted; Nos. 1, 3–24 inclusive, 26, 30–32 inclusive and 34 are nearly exhausted, a few copies of each remaining, which can only be supplied to complete sets for libraries; Nos. 25, 27–29 inclusive, 33, 35–43 inclusive, and the index number are still in stock.

ANNUAL REPORT

Of George F. Mills, *Treasurer pro tem.*, of the Hatch Experiment Station of Massachusetts Agricultural College,

For the Year ending June 30, 1896.

Cash received from United States treasurer,		$15,000 00
Cash paid for salaries,	$5,218 50	
for labor,	3,541 94	
for publications,	2,816 86	
for postage and stationery,	284 66	
for freight and express,	185 60	
for heat, light and water,	110 15	
for seeds, plants and sundry supplies,	572 98	
for fertilizers,	96 88	
for feeding stuffs,	291 51	
for library,	686 83	
for tools, implements and machinery,	326 63	
for furniture and fixtures,	70 47	
for scientific apparatus,	96 00	
for travelling expenses,	92 31	
for contingent expenses,	155 11	
for building and repairs,	453 57	
		$15,000 00
On hand July 1, 1895: —		
Received from Dr. Goessmann,	$1,704 37	
from State treasurer,	10,000 00	
from fertilizer fees,	3,627 17	
from farm products,	1,204 46	
from miscellaneous,	733 64	
		$17,269 64
Cash paid for salaries,	$9,502 66	
for labor,	434 02	
for publications,	115 37	
for postage and stationery,	186 64	
for freight and express,	127 77	
Amounts carried forward,	$10,366 46	$17,269 64

Amounts brought forward,	$10,366 46	$17,269 64
Cash paid for heat, light and water,	287 31	
for chemical supplies,	901 98	
for seeds, plants and sundry supplies,	475 34	
for fertilizers,	825 01	
for feeding stuffs,	484 58	
for library,	332 86	
for tools, implements and machinery,	15 15	
for furniture and fixtures,	311 98	
for scientific apparatus,	15 50	
for live stock,	365 00	
for travelling expenses,	17 19	
for contingent expenses,	491 66	
for building and repairs,	1,336 70	
Balance,	1,042 92	
		$17,269 64

Amherst, Mass., Aug. 31, 1896.

I, Charles A. Gleason, duly appointed auditor of the corporation, do hereby certify that I have examined the books and accounts of the Hatch Experiment Station of the Massachusetts Agricultural College for the fiscal year ending June 30, 1896; that I have found the books well kept and the accounts correctly classified as above, and that the receipts for the year are shown to be $32,269.64 and the corresponding disbursements $31,226.72. All the proper vouchers are on file, and have been by me examined and found to be correct, there being a balance of $1,042.92 on accounts of the fiscal year ending June 30, 1896.

CHARLES A. GLEASON,
Auditor.

REPORT OF THE AGRICULTURIST.

WILLIAM P. BROOKS.

Leading Results and Conclusions based upon the Experiments outlined in the Report of the Agriculturist.

Cabbages and Swedes.

1. Soil-test work indicates that fertilizers for these crops should be particularly rich in available phosphoric acid and potash.
2. The muriate of potash has been found a useful form in which to supply the potash.
3. The material used to supply phosphoric acid in our experiment was dissolved bone-black, but it is believed that other available phosphoric acid fertilizers will be found equally serviceable.

Soy Beans.

1. Soil-test work shows a very intimate connection between potash supply and the growth of this crop.
2. The form in which potash has been supplied in soil tests is the muriate, but other experiments indicate that the sulphate is superior to this salt for beans.

Corn.

Soil Test with Corn. — A carefully conducted soil test with corn in Norwell, Plymouth County, upon somewhat exhausted soil, previously for many years in grass, shows potash to be here the controlling element for this crop, as in so many other places.

Hill v. Drill Culture of Corn. — Experiments continued in different fields from five to six years indicate that corn planted in drills will usually produce larger crops than when planted in hills. This increase is most marked, as might be expected, in case of the stover, but applies to the grain as well.

Green Manuring in Continuous Corn Culture.

1. *White mustard*, sown in standing corn at the time of the last cultivation, helps to keep down weeds, furnishes useful pasturage for sheep or young stock, conserves soil nitrogen, does not decrease the yield of corn the year it is sown, and can be counted upon to improve the soil if turned under. *It also helps largely to prevent soil washing in winter.*

2. *Crimson and sweet clovers* have not proved to be suited for green manuring crops in continuous corn culture, since they are not sufficiently hardy.

VARIETY TESTS.

Potatoes.

1. Of 60 varieties of potatoes cultivated, but 5 showed themselves to be in any marked degree superior as crop producers to the Early Rose and Beauty of Hebron.

2. These, with rates of yield per acre in bushels, are as follows: Carman No. 1, merchantable, 355.3; small, 28.6. Fillbasket, merchantable, 336; small, 24.5. New Satisfaction, merchantable, 306; small, 25.7. Early Maine, merchantable, 305.1; small, 35.6. Dutton's Seedling, merchantable, 304.5; small, 19.8.

3. The Early Rose yielded: merchantable, 292.8; small, 21 bushels. The Beauty of Hebron (somewhat injured by proximity to other crops), merchantable, 275.9; small, 18.7 bushels.

4. The varieties tested showed no very marked differences in respect to ability to resist blight.

Corn.

1. Of 21 varieties of Flint corn cultivated, 7, or $33\frac{1}{3}$ per cent., gave a yield at the rate of $83\frac{1}{3}$ bushels per acre or over.

2. Of 46 varieties of Dent corn, 13, or 28 per cent., equalled or exceeded the same rate of production.

3. Among the best of the Flint varieties are the White Flint,* Sanford,* Compton's Early, Giant Long White and Longfellow.

4. Among the best Dent varieties as indicated by our trial are Yellow Rose, Mastodon, Reed's Yellow Dent, New Golden Triumph and Leaming; but Sibley's Pride of the North, though standing ninth in weight of ears produced, matured among the earliest, and is undoubtedly one of the best Dent varieties for grain production.

Clovers.

1. Crimson clover can be grown as an annual, and gives one good crop; but it will not usually survive our winters, and does not, therefore, at present appear to be worthy of attention as a fodder crop.

2. The mammoth clover exceeds the common red in productive capacity, having produced more hay in two cuttings than the common red in three. It is especially to be commended for sowing with timothy.

3. Alsike clover appears not to be as long lived as the mammoth and the common red.

Millets.

1. For seed production the Japanese "barn-yard" and the Japanese "common" again show their superiority, producing respectively 57 and 53.3 bushels per acre.

2. As a result of a careful comparison of 17 varieties, the Japanese white-seeded panicle millet and the Japanese barn-yard millet are found to lead all other varieties in productive capacity.

---

* These two are apparently nearly or quite identical.

New Crops.

The flat pea (*Lathyrus sylvestris*) has not been found to be of value as a fodder crop.

The horse bean (*Vicia faba*) has not been found to do well.

Sorghum of different varieties appears inferior to Indian corn as a fodder crop.

Saccaline is found not to be hardy and will probably not prove of value as a fodder crop.

Miscellaneous.

Fungiroid has not been found effective in preventing potato blight.

Sulphur applied in the drill did not prevent scab of potatoes.

The Symmes' hay cap is preferred to cloth caps.

SOIL TESTS.

Soil tests, upon the plan outlined in previous reports, have been carried on upon a somewhat less extensive scale. We have had four such experiments this year: one with soy beans and one with turnips and cabbages upon our own grounds; and one in Montague and another in Norwell, with corn. Circumstances compelled the cessation of the work in Concord, Worcester and Shelburne, and it was not considered important to continue it longer in Hadley, as this town lies so near Amherst, and as the soil upon which we were working gave results so entirely similar to those obtained upon our own. The main conclusions justified by the results of the past season are as follows: —

1. Potash is the controlling element in the case of the corn crop in Norwell.

2. Nitrogen appears to have been the most useful element for the corn crop in Montague; but the results are obscured in a measure by differences in natural fertility in different parts of the field.

3. A combination of potash and phosphoric acid appears to be necessary to materially increase either the cabbage or the turnip crops in Amherst.

4. Potash proves much the most useful single element for the soy-bean crop in Amherst.

1. *Soil Tests with Corn.*

In Montague the experiment was carried out upon land belonging to Mr. H. M. Lyman, and is the first year this land has been used in such work. The field selected is level, and it was thought it would be suited for the purpose, though it had been more recently manured than we would have liked. The results show that it was not as even in fertility as is desirable. The yields of the five scattered nothing plats were respectively at the rates of 12, 10.5, 19, 32 and 19.9 bushels per acre. Under such conditions, we are not justified in attempting to draw general conclusions. The nitrate of soda appears to have produced an average increase at the rate of: grain, 11 bushels; stover, 158.5 pounds per acre. The average effect of the phosphate appears to have been a decrease in both grain and stover, while the potash appears to have increased the stover slightly but not the grain.

In Norwell the experiment was carried out upon land belonging to the writer, and is the first year this land has been used in such work. The field was in grass in 1895, and is in rather a low state of fertility. Throughout the season potash seemed to be the controlling element. At the time of harvesting, plat 5, receiving muriate of potash alone at the rate of 160 pounds per acre, appeared to be as heavy as either plats 10 or 13, receiving respectively complete fertilizer and stable manure. Owing to a slight accident at the time of harvesting, figures cannot be published at this time.

2. *Soil Test with Cabbages.*

This test occupied one-half of the land which has been designated the "north acre" in previous reports, the other half being occupied with Swedish turnips. The acre was divided by a line running through the middle across the plats, the one end being devoted to cabbages, the other to turnips.

This acre had been for five years devoted to soil-test work, the crops in order of succession having been corn, potatoes, soy beans, grass and clover, and grass and clover. During this time the nothing plats have received no manure or fertilizer of any kind. The variety of cabbages raised was Fottler's Drumhead. The seed was planted in the field. The average yield of the nothing plats was at the rate of 2,470 pounds of hard and 7,190 pounds of soft cabbages per acre.

The average result of the application of phosphoric acid was an increase at the rate per acre: hard heads, 9,557.5 pounds; soft heads, 1,912.5 pounds, — a profit from the use of phosphate amounting to $23.08 per acre. The use of the phosphate without potash, however, had practically no effect upon the crop.

The average increase apparently due to the potash is at the rate per acre: hard heads, 10,147.5 pounds; while there is an average decrease in soft heads at the rate of 527.5 pounds per acre. The net average result of the use of potash is profit at the rate of $21.51 per acre. The potash, even without the phosphoric acid, produces a considerable increase, but produces two and one-half times as great an increase in combination with a phosphate.

The nitrogen is much less useful. The average is at the rate of 2,627.5 pounds increase in hard heads and 402.5 pounds decrease in soft heads, per acre. It produces the largest increase when used with phosphate. The net result of the use of nitrate of soda is a gain at the rate of $6.07 per acre.

The results are not as clear in their indications as could be wished, though they point to a close dependence of this crop upon both potash and phosphoric acid manuring. The experiment will be repeated when opportunity offers.

3. *Soil Test with Swedish Turnips.*

This crop, as stated above, occupied one-half of the acre on which the test with cabbages was carried out. The variety was Laing's Swedish turnip, sown June 13. The results show a close agreement with those obtained with the cabbages. The average of the nothing plats was at the rate of 10,250 pounds per acre.

The average result of the use of phosphoric acid (dissolved bone-black) was an increase at the rate of 6,308.5 pounds per acre. Similar averages for the potash (muriate) and nitrogen (nitrate of soda) were, respectively, 7,255 and 2,891.7 pounds. The net average profits are at the rates per acre: for the phosphoric acid, $9.42; for the potash, $11.35; and for the nitrate, $2.58.

Here, as with the cabbages, the combination of phosphoric acid and potash seems essential to large increase in the crop. The phosphoric acid without potash gives no increase; with potash alone, an increase at the rate of 11,700 pounds per acre. The potash alone gives an increase of but 400 pounds per acre, but with the phosphate it gives an increase of 13,633 pounds per acre.

The combination of phosphate and potash gives an increase at the rate of 12,100 pounds per acre, as compared with the nothing plats nearest to the one on which it was used.

4. *Soil Test with Soy Beans, Amherst, South Acre.*

This is the eighth season of soil-test work upon this acre. The beans, variety Medium Green, were sown May 19, in drills 2½ feet apart, requiring 25 pounds seed for the acre. The nothing plats produced an average of 350 pounds beans and 757½ pounds straw per acre.

Potash (muriate) appears to be the most useful element, giving an average increase per acre of 646⅔ pounds beans and 451⅔ pounds straw. The average increase per acre caused by phosphoric acid (dissolved bone-black) was 126⅔ pounds beans and 250 pounds straw. Similar average for nitrogen (nitrate of soda) was 13½ pounds beans and 116⅔ pounds straw. Nitrogen produced a decrease, except when used with both phosphoric acid and potash.

In appearance the beans grown upon potash were larger and plumper than those grown upon either phosphoric acid or nitrogen.

MANURING THE CORN CROP.

1. *Manure alone v. Manure and Potash.*

The past is the sixth year of continuous culture of corn upon the same acre of land for the purpose of testing the relative value of an application yearly of a small quantity of *manure* with *muriate of potash*, as compared with a larger application of *manure alone*. When manure alone was applied, it was put on at the rate of 6 cords per acre, being spread broadcast after ploughing, and harrowed in. The manure and potash similarly applied have been put on at the rate of 4 cords of the former and 160 pounds of muriate of potash for the latter.

The plats, four in number, contain one-quarter of an acre each. The results are shown below : —

Plat 1, manure, 8,115 pounds: stover, 1,600 pounds; ear corn, 1,530 pounds.
Plat 2, manure, 5,354 pounds; muriate of potash, 40 pounds: stover, 1,300 pounds; ear corn, 1,455 pounds.
Plat 3, manure, 8,981 pounds: stover, 1,255 pounds; ear corn, 1,450 pounds.
Plat 4, manure, 5,711 pounds; muriate of potash, 40 pounds: stover, 970 pounds; ear corn, 1,120 pounds.

In plats 3 and 4 the corn was planted in hills, while in 1 and 2 it was planted in drills. This no doubt accounts in a measure for the considerable difference in yield. The inferiority of the crop from plat 4 is due to the fact that, from force of circumstances, poorer manure was used upon it in 1895 than upon the other plats.

Averaging the results upon 1 and 3 and upon 2 and 4, we find the yields have been at the following rates per acre : —

With manure alone: stover, 5,710 pounds; grain, 73¼ bushels.
With manure and potash: stover, 4,540 pounds; grain, 64⅝ bushels.

In no one of the six years during which this experiment has been continued has the crop raised on the combination of manure with potash equalled that raised on a larger quantity of manure alone; but the differences have been small, and in no case has the value of the excess in crop produced by the larger quantity of manure been sufficient to cover the excess in cost of the manure applied. The difference in crop is this year considerably larger than in any preceding year; and, as this difference has been quite steadily increasing, we are justified in concluding that the manure and potash in the quantities employed cannot fully take the place of the larger application of manure in continuous corn culture. It is true the crop where the manure and potash are employed is still an excellent one, averaging for the two plats at the rate of more than 63 bushels per acre. Continuous corn culture is not, however, the rule, nor indeed under most circumstances advisable, though often proved to be possible, at least for many years; and therefore this land has now been seeded to grass and clover, for the purpose of determining to what extent, if any, the introduction of these crops will enable the farmer under the given manuring to secure equal crops with both systems.

2. *Special Corn Fertilizer v. Fertilizer containing More Potash.*

This experiment in continuous corn culture was begun in 1891, and the present is, therefore, the sixth season. The object in view is a comparison of the results obtained with a fertilizer proportioned like the average of the "*special*" *corn fertilizers* found upon our markets in 1891 with those obtained with a fertilizer richer in potash but furnishing less nitrogen and phosphoric acid. The results in previous years have indicated the financial advantage to lie with the latter fertilizer.

Four plats of one-fourth of an acre each are devoted to this experiment, which are respectively numbered 1, 2, 3 and 4.

The materials applied to the several plats are shown below: —

FERTILIZERS.	Plats 1 and 3 (Pounds Each).	Plats 2 and 4 (Pounds Each).
Nitrate of soda,	20	18
Dried blood,	30	30
Dry ground fish,	30	20
Plain superphosphate,	226	120
Muriate of potash,	22.5	60
Cost of materials per plat,	$3 23	$3 10

The materials supplied to plats 1 and 3 would furnish per acre the quantities of nitrogen, phosphoric acid and potash found in 1,200 pounds of fertilizer having the average composition of the "special" corn fertilizers upon the market at the time the experiment was commenced, viz., 1891. The average price per plat for 300 pounds of such fertilizer (the amount needed per plat to equal the above materials) is about $5.25.

The yields the past year are shown below: —

Plat 1, "special" fertilizer: stover, 935 pounds; ear corn, 1,110 pounds.
Plat 2, fertilizer richer in potash: stover, 995 pounds; ear corn, 1,030 pounds.
Plat 3, "special" fertilizer: stover, 790 pounds; ear corn, 1,135 pounds.
Plat 4, fertilizer richer in potash: stover, 865 pounds; ear corn, 1,065 pounds.

Computed to the acre and the grain in bushels, the averages are: "special," stover, 3,450 pounds; grain, 56.1 bushels; fertilizer richer in potash, stover, 3,720 pounds; grain, 52.4 bushels. It will be noticed that the "special" fertilizer gives rather more grain and less stover than the fertilizer richer in potash. This result is in entire accord with the results of previous years, and the indications are strong, therefore, that our mixture "richer in potash" needs modification to make it equal in grain-producing power to the "special" fertilizer for *continuous corn culture*. It is still my belief, however, that under ordinary farm conditions the "*fertilizer richer in potash*" would be found equal at least to the "special," for under such conditions grass and clover would alternate with the corn; the clover, judging from facts almost universally noticed, would thrive better where more potash had been used, and as a result the soil would be enriched in nitrogen, which would be favorable to the development of the succeeding corn crop. In all of our "soil-test" work the nitrogen has ranked next to the potash in benefit to this crop. With a view to testing the correctness of this conclusion, the land used for this experiment has now been seeded to grass and clover, and after two or three years will again be planted with corn.

The average crop raised on the "special" fertilizer this year is worth $0.83 more per acre than the average for the fertilizer richer in potash; the fertilizer materials used cost $0.52 more. There is no material difference, therefore, in the financial outcome of the two systems under the given conditions; but, as above pointed out, should the farmer purchase a manufactured "*special*" *corn fertilizer*, it would have cost him about $5.25 per plat, or $21 per acre, to procure equal amounts of the essential elements of plant food. Since the "*fertilizer richer in potash*" cost $3.10 per plat, or $12.40 per acre, while the crop was practically almost as valuable as that produced on the "special," it follows that here is a possible saving of almost $8 per acre in initial expenditure. It is true that the materials recommended require mixing, while the "special" fertilizer is already mixed. It is not true that the elements of plant food in the "special" are in better forms, or more available. In conclusion, however, it is but fair to state that the prices used in calculating the cost of the "*materials*" are cash prices, while the price of the "special" is determined in a measure by the fact that credit must often be given for such goods.

Hill v. Drill Culture for Corn.

In each of the two experiments above described one-half of each acre has each year been planted in drills and the other half in hills. Plats 1 and 2 in each case have been planted in drills, and plats 3 and 4 in hills. The distance between the rows under both systems has been $3\frac{1}{2}$ feet. Under the "drill" system, the plants have been thinned to 1 foot; under the "hill" system, the hills are 3 feet apart and the plants are thinned to three in a hill. We thus have equal numbers of plants under the two systems. The results the past year average as follows: for the acre receiving manure, drill culture, at rate per acre, stover, 5,800 pounds; grain, $74\frac{5}{8}$ bushels; hill culture, at rate per acre, stover, 4,450 pounds; grain, 63 bushels; for the acre receiving fertilizer similar averages are, drill culture, stover, 3,630 pounds; grain, $53\frac{7}{8}$ bushels; hill culture, stover, 3,540 pounds; grain, $54\frac{5}{8}$ bushels. Averaging both experiments, we have, for drill culture, stover, 4,715 pounds; grain, $64\frac{1}{4}$ bushels; for hill culture, stover, 3,995 pounds; grain, $58.\frac{4}{5}$ bushels.

Green Manuring in Continuous Corn Culture.

White mustard as a crop for green manuring and nitrogen conservation was sown on one-half the acre where *manure alone* has been under comparison with *manure and potash* in each of the years from 1892 to 1894 inclusive, the seed being scattered in the standing corn late in July in each year. The growth varied greatly from year to year, but the practice proved beneficial. In 1895 the increase in the corn crop apparently due to the culture of the mustard amounted to: stover, 452 pounds; grain, 5.4 bushels. In July, 1895, the mustard was sown only on one-quarter of the acre, and, because of a very dry and hot autumn, the growth was light. The crop on this quarter this year shows an increase as compared with the quarter not so treated of: stover, 680 pounds; grain, 3 bushels, per acre.

The other plat, which had been sown with mustard in preceding years, was in 1895 sown with rye on September 5, at the rate of 3 bushels per acre. The growth was good, and the rye, when ploughed in on May 11, was 18 inches tall. The apparent result of this treatment is a decrease in crop at the rate per acre: stover, 700 pounds; grain, $4\frac{3}{4}$ bushels. It seems impossible to believe that the effect of this treatment can be permanently injurious. The decrease in yield this year may be due to the fact that considerable available plant food which was locked up in the rye has not yet by the decay of the vegetable matter of this crop become again available. If this be the true explanation, then in the next year the beneficial effect of the green manuring should become apparent.

On the acre where "*special*" *corn fertilizer* has been under comparison with *fertilizer richer in potash* some crop of *the clover family* has been sown in the standing corn each year since 1893; but the crops themselves have been under trial, and have not shown themselves fitted for the purpose in view. Thus, in 1893 and 1894 *crimson clover* was tried, but each following spring the crop was killed and the results were unimportant. In July, 1895, *sweet clover* (*Melilotus alba*) was sown upon one quarter and common *red clover* upon another. The *sweet clover* was badly thrown out by the frost, and hardly a plant survived; while the red clover starts too late in spring to have made much growth before it must be turned in. The results are unimportant in both cases, though the crop this year is somewhat greater where the red clover was sown, viz., at the rate of 55.25 bushels per acre, against 52.75 bushels where no clover was sown.

VARIETY TESTS.

1. Potatoes.

In the spring of 1895 we procured as far as possible seed of all prominent and new varieties of potatoes, necessarily from widely scattered and very different sources. This seed was planted for the purpose of raising under like conditions a stock of the different sorts, which, having been produced under identical conditions and in every respect handled alike, it was thought would be suited for a comparative test of varieties. Sixty varieties, the seed of which (in every instance save one) was raised upon our own grounds last season, have been made the subject of such a comparative trial this year. The variety the seed of which was from another source is Carman No. 1. Our seed of this sort raised last year was accidentally destroyed, and, as the variety is a prominent one, it was thought best to procure enough for this trial from a prominent grower in this State, Dr. Jabez Fisher of Fitchburg. Of most varieties we planted 2 rows, each 209 feet long; but in some cases, where the seed was insufficient, only 1 row was planted.

The seed was washed and treated with a solution (2 ounces to 15 gallons of water) of corrosive sublimate on April 13. The tubers were then placed on the earth in a cold frame without glass, where they were allowed to remain until May 1, when they were cut into pieces having two eyes each, and of as nearly equal size as possible. At this time the tubers had sent out numerous thick green sprouts, which were perhaps about one-eighth to one-fourth of an inch in length. The tubers when cut were rolled in plaster. They were planted on May 5 and 6, the pieces being placed just 1 foot apart in the rows. In those cases where the supply of seed was insufficient to plant a full row, the row was filled out with seed of the Beauty of Hebron, that there might be no vacancies.

The treatment of the seed with corrosive sublimate solution entirely prevented scab, and the system followed in sprouting the tubers was eminently satisfactory. It should perhaps be stated that when the sun shone hot the tubers were covered with a sheet of thin white cotton cloth. But for this protection it is to be feared that in a cold frame they might get overheated on excessively hot days.

The land where the test was made was last year in millet and soy beans, the rows this year running across the divisions of last season, so that each row of this year is exactly comparable with every other. The soil is a medium loam, well adapted to the potato. Fertilizers only were applied, and at the following rates per acre: nitrate of soda, 240 pounds; dried blood, 100 pounds; tankage, 240 pounds; plain superphosphate, 400 pounds, and high-grade sulphate of potash, 250 pounds. These materials were mixed and strewn in the furrows before the seed was dropped. All needful operations were seasonably and thoroughly carried out. The season was on the whole favorable, so that the crop suffered from no unusual conditions. Careful notes were taken throughout the season, covering all peculiarities in growth and development, time of blossoming, etc. All varieties suffered somewhat from early blight (*Macrosporium solani*). This was first discovered on 1 variety on July 18. By the 22d it could be detected on 26 other varieties, and by August 3 all except 1 were affected. As early as August 8 the vines of 17 varieties were entirely dead. Between the 8th and 20th the vines of 26 other varieties died, while by August 29 all were dead.

An attempt to prevent this blight by repeated applications of "Fungiroid" was an entire failure. It will be noticed that considerable differences in degree of susceptibility to "blight" showed themselves. Until the varieties have been further tested, however, it is not deemed advisable to publish the details.

The crop was harvested in part on September 10–12, and the balance September 24–25. There was no rot, and the tubers were for the most part smooth and handsome.

The yield has been in every case corrected to 207 hills or sets, so that the results are strictly comparable. The area occupied by this number of hills is almost exactly one-seventieth part of an acre; so that, to bring out the significance of the differences more clearly, I have multiplied the results by seventy, and converted into bushels, thus showing the *rate per acre* yielded by the different sorts.

The varieties are reported in alphabetical order, and for each the tubers are divided into the customary classes, viz., merchantable and small.

Varieties of Potatoes, Yield per Acre (Bushels).

NAME.	Merchantable Tubers.	Small Tubers.
Alexander's Prolific,	123.3	14.0
Alliance,	285.8	42.0
Beauty of Hebron,	275.9	18.7
Bill Nye,	226.3	25.7
Bliss's Triumph,	276.5	25.7
Burbank's Seedling,	207.7	23.3
Burpee's Extra Early,	208.8	49.0
Carman No. 1,	355.3	28.6
Carman No 3,	199.5	16.9
Chance,	201.8	30.3

Varieties of Potatoes, Yield per Acre (Bushels) — Concluded.

NAME.	Merchantable Tubers.	Small Tubers.
Clarke No. 1,	255.5	26.8
Columbus,	265.4	33.3
Crown Jewel,	169.1	29.2
Dakota Red,	283.5	28.0
Delaware,	235.7	22.2
Dutton's Seedling,	304.5	19.8
Early Essex,	162.2	35.0
Early Harvest,	234.5	44.3
Early Maine,	305.1	35.6
Early Market,	229.9	28.6
Early May,	232.8	22.2
Early Northern,	266.0	42.0
Early Ohio,	159.8	17.5
Early Ohio, Jr.,	232.8	25.1
Early Rose,	292.8	21.0
Early Sunrise,	268.3	32.7
Empire State,	271.3	12.3
Fillbasket,	336.0	24.5
Freeman's,	203.6	30.9
Hampden Beauty,	232.8	27.4
Hampden Chief,	187.8	4.7
Henderson's Early Puritan,	250.8	34.4
Irish Daisy,	172.1	59.1
Late Puritan,	277.1	28.0
Maggie Murphy,	227.5	28.0
Merriman,	266.6	44.9
Monroe Co. Prize.	240.3	31.5
Monroe Co. Seedling,	248.5	21.0
New Ideal,	204.2	8.2
New Queen,	255.5	49.2
New Satisfaction,	306.8	25.7
Onward,	200.7	26.3
Polaris,	149.3	31.5
Pride of the West,	243.8	26.8
Quick Return,	239.8	29.8
Restaurant,	259.0	21.6
Rochester Rose,	272.4	31.5
Rural New Yorker No. 2,	218.8	22.2
Sir William,	282.9	19.8
Six Weeks,	141.8	20.4
Snow Flake,	169.8	32.1
State of Maine,	252.6	34.4
Summit,	246.8	28.6
Sunlit Star,	232.8	41.4
Thorburn,	255.5	31.5
Vanguard,	255.5	30.9
White Elephant,	295.8	23.9
White Star,	235.1	28.0
Woodbury's White,	289.3	26.3
World's Fair,	145.8	26.8

A study of these figures reveals the fact that there are wide differences in yield; but it is noteworthy that the yield of such old standard sorts as the Early Rose and Beauty of Hebron stands far above the average. The yield of the Early Rose is exceeded by but 6 varieties, viz., Carman No. 1, Fillbasket, New Satisfaction, Early Maine, Dutton's Seedling and White Elephant, named in the order of superiority. In addition to these, 6 other varieties, viz., Woodbury's White, Alliance, Dakota Red, Sir William, Late Puritan and Bliss's Triumph slightly exceed the yield of the Beauty of Hebron. In justice to this variety, it is proper to state that it occupied an outside row adjoining land planted to millet, rape and mustard, and was undoubtedly somewhat injured by its proximity to these, as their growth was exceptionally rank. It may well be doubted whether, under precisely equal conditions, the Beauty of Hebron would have been exceeded in yield by a larger number of varieties than was the Early Rose.

The varieties especially noteworthy for large yield in the order of actual production of merchantable tubers, then, with rates per acre in bushels, are the following: Carman No. 1, 355.3; Fillbasket, 336; New Satisfaction, 306.8; Early Maine, 305.1; Dutton's Seedling, 304.5; White Elephant, 295.8; Early Rose, 292.8; Woodbury's White, 289.3; Alliance, 285.8; Dakota Red, 283.5; Sir William, 282.9; Late Puritan, 277.1; Bliss's Triumph, 276.5; and Beauty of Hebron, 275.9. These varieties will all be tested as to eating and keeping qualities.

Seed of 21 other varieties has this season been procured in small amounts from various sources, and the tubers produced from these will be preserved for comparison another season. Ten of these have given a yield at the rate of more than 300 bushels of merchantable tubers per acre, and are therefore very promising.

2. *Corn.*

Sixty-seven varieties of field corn have been under trial upon a small scale, for the purpose of preliminary observations as to merits and adaptability to different uses; 21 of these were Flint and 46 Dent varieties. Three rows (each

75 feet long) of each variety, with one or two exceptions where not sufficient seed could be obtained, were planted. The trial has involved a large expenditure of time and attention. Notes have been taken from day to day, covering such points as germination, dates of tasselling and silking, height, relative leafiness, time of cutting, etc. The autumn was exceptionally unfavorable to curing of the corn crop; and hence, though an exact record of the weights of product (sound hard ears, soft ears and stover) has been made, it is of less value as a basis for comparative judgment than would ordinarily be the case. Particularly is this true in relation to the stover of the later Dent varieties.

The field used for this trial was in corn last year. The soil is a medium heavy loam, and quite even in quality throughout. *A fertilizer supplying, per acre, nitrate of soda, 72 pounds; dried blood, 120 pounds; dry ground fish, 80 pounds; plain superphosphates, 480 pounds; and muriate of potash, 240 pounds, was applied broadcast after ploughing, and harrowed in.* The rows were uniformly spaced throughout the field, viz., 3½ feet apart. The corn was so planted in checks that when thinned it stood, single plants, at the following intervals in the row: *for all Flint varieties*, 8 inches; for the earlier Dents, 10 inches; and for the later Dents, 12 inches.

Without going into much detail, I have to report further concerning this trial: —

1. That the following pairs of varieties appear to be nearly if not quite identical: —

Champion White Pearl and White Pearl.
Buckbee's No. 7 and Colossal.
White Cap Dent and White Cap Yellow Dent.
Sanford and White Flint.
Rideout and Longfellow.
Dibble's Early Mammoth and Houghton's Silver White Flint.

2. The yield of ear corn all or nearly all of which was sound and well cured varied: for the Flint varieties, between 79 and 130 pounds; for the Dent varieties, between 78 and 144 pounds.

3. Seven out of the 21 Flints gave a yield of 120 pounds* or over; 13 of the 46 Dents gave a similar yield, but with a larger proportion of imperfectly cured ears; 33 per cent. of the Flints and 28 per cent. of the Dents, therefore, come into this class.

4. The yield of stover varied: for the Flint corns, between 104 and 245 pounds; for the Dent corns, between 94 and 451 pounds. Some of the Dents giving high yields of stover were far from perfectly cured.

5. The order of rank in yield of ears of the best 5 Flint varieties was as follows: White Flint, Sanford, Compton's Early, Giant Long White and Longfellow.

6. The best 5 Dent varieties in order of ear production are: Yellow Rose, Mastodon, Reed's Yellow Dent, New Golden Triumph and Leaming.

7. Sibley's Pride of the North, very thoroughly matured, ranks ninth in production of ears, and is undoubtedly one of the best Dent varieties for grain production.

8. The following varieties appear to be unsuited to our locality, on account of being too late: Brazilian, Farmer's Favorite, Queen of the Prairie, Golden Beauty, Golden Dent, Legal Tender, Mammoth White Surprise and Dr. Woodhull.

9. Three other varieties are certainly too late for culture as grain crops, but appear to promise well for the silo, viz., New Golden Triumph, Hickory King and Mastodon.

3. Clovers.

Four varieties of clover have been given a thorough comparative trial, viz., mammoth (*Trifolium medium*), common red (*T. pratense*), alsike (*T. hybridum*) and crimson (*T. incarnatum*). The soil of Field B is a medium heavy loam, but thoroughly drained. For some twelve years it has been manured only with ground steamed bone and potash salts. The plats are one-tenth of an acre each in size. Every plat is manured yearly with ground bone, at the rate of 600 pounds to the acre; one-half of these plats receive yearly an application of muriate of potash at the rate of 200 pounds per acre, and the other half receive the same quantity of high-grade sulphate of potash. The land was occupied by grain crops cut for fodder in 1895. Soon after the fodder was removed the land was ploughed, and the seed was sown on August 1. Of the mammoth and common red clovers, 3 pounds of seed per plat were sown; of the alsike clover, 2½ pounds; and of the crimson clover, 4 pounds. The seed of all varieties started promptly and well and all varieties went into the winter in excellent condition.

---

* A yield of 120 pounds corresponds to a product of 83⅓ bushels shelled grain per acre.

The crimson clover early in March appeared to be in good condition, but during the latter weeks of March it gradually weakened and died. By the first of April there was scarcely a plant in the field alive. This species appears unable to endure our average spring weather. The crimson clover plats were accordingly ploughed in April and resown, 5½ pounds of seed per plat being used, on April 24. The seed started quickly, and, as will be seen by the tables which follow, this variety gave one good crop, at the rate of nearly 3 tons to the acre on the best plat. This clover was cut on July 17, at which time it was in *mid-bloom*. Notwithstanding frequent showers soon after, the stubble failed to start, and in a few weeks was almost entirely dead, at which time the plats were reploughed. It will undoubtedly be found necessary to cut this variety just as it begins to bloom, in order to insure later cuttings.

The very few plants in this field (as well as those from another with lighter soil) which survived the early spring weather were taken up and replanted, in order to secure seed, in the hope that we may in time by a continuance of this process of selection produce a strain or variety of this species which will prove hardy with us.

For culture as an annual it seems unlikely that crimson clover will prove of much importance, as in that case it would not give earlier fodder than the other clovers. Could it be cultivated as a winter annual, on the contrary, it must take an important place as a crop both for fodder and for green manuring, — for fodder chiefly, because it would be ready to cut at so early a date, and for green manuring, since it grows so rapidly.

Mammoth Clover. — This variety was cut on June 23, at which time it was not in full bloom. It was thought best to harvest, as it was lodging badly. On August 10 it was cut for the second time. It did not make sufficient growth thereafter to warrant cutting again. Though cut, therefore, but twice, while the common red clover was cut three times, the mammoth clover produced slightly more hay than the former. The two crops make a yield at the rate of rather more than 4½ tons per acre. This hay is not objectionably coarse, or, rather, not much more so than that of the common red variety. This mammoth clover, as will be seen by reference to the table below showing composition of the crops, is not inferior in nutritive value to the common. The mammoth is to be especially recommended for sowing in mixtures of which timothy is a prominent part, as it matures more nearly with this grass than does the common red.

Common red clover calls for little special comment. Each of the three cuttings was made when the crop was a little past full bloom; the dates, June 19, July 28 and October 9. The average total yield of the plats (one-tenth of an acre each) is at the rate of a little more than 4¼ tons per acre. The composition of this variety will be found in the table which follows those showing yield and dry matter.

Alsike clover gave two excellent crops, cut respectively on June 19 and August 10: but, while the sod of both the mammoth and common red on November 3 appeared to be in excellent condition, the sod of this variety shows signs of weakness. Weeds are coming in to a considerable extent, principally sorrel. The table of composition shows this clover to be somewhat richer in nitrogenous nutrients (protein) than either of the others. This difference in its favor is in part offset by lower percentages of fat and extract, and it is doubtful whether the hay of this variety is worth more for food than that of either of the others. Alsike clover is especially recommended for soils which are rather too moist for the common red variety.

FIELD B. — *Trial of Clovers (Bone at Rate of 600 Pounds per Acre to All Plats).*

	MAMMOTH CLOVER.		COMMON RED CLOVER.		ALSIKE CLOVER.		CRIMSON CLOVER.	
	Plat 13. Muriate of Potash.	Plat 14. Sulphate of Potash.	Plat 15. Muriate of Potash.	Plat 16. Sulphate of Potash.	Plat 17. Muriate of Potash.	Plat 18. Sulphate of Potash.	Plat 19. Muriate of Potash.	Plat 20. Sulphate of Potash.
	Pounds.	Pounds.	Pounds.	Pounds.	Pounds.	Pounds.	Pounds.	Pounds.
First crop,	615	650	455	455	620	455	575	595
Second crop,	295	305	276	294	325	200	-	-
Third crop,	-	-	120	120	-	-	-	-
Total crop,	910	955	851	869	945	655	575	595

FIELD B. — *Clovers (Dry Matter in the Crops).*

	MAMMOTH CLOVER.				COMMON RED CLOVER.				ALSIKE CLOVER.				CRIMSON CLOVER.			
	PLAT 13.		PLAT 14.		PLAT 15.		PLAT 16.		PLAT 17.		PLAT 18.		PLAT 19.		PLAT 20.	
	Per Cent.	Pounds.	Per Cent.	Pounds.	Per Cent.	Pounds.	Per Cent.	Pounds.	Per Cent	Pounds.	Per Cent.	Pounds.	Per Cent.	Pounds.	Per Cent.	Pounds.
First crop,	83.19	511.6	83.32	541.6	82.1	373.5	85.7	390.1	74.0	458.5	78.4	356.5	73.6	422.9	68.4	406.9
Second crop,	83.06	245.1	83.52	254.7	77.3	213.2	78.4	230.5	84.6	274.7	81.0	162.0	-	-	-	-
Third crop,	-	-	-	-	83.3	99.9	83.3	99.9	-	-	-	-	-	-	-	-
Total dry matter,	756.7		796.3		686.6		720.5		733.2		518.5		422.9		406.9	

Composition of Clover Hay.

POTASH SALT.	MAMMOTH.		COMMON RED.		ALSIKE.	
	Muriate (Per Cent.).	Sulphate (Per Cent.).	Muriate (Per Cent.).	Sulphate (Per Cent.).	Muriate (Per Cent.).	Sulphate (Per Cent.).
Water,	16.81	16.88	17.92	14.26	26.05	21.64
Dry matter,	83.19	83.32	82.08	85.74	73.95	78.36
	100.00	100.00	100.00	100.00	100.00	100.00
Dry matter contains:—						
Crude ash,	9.97	8.96	8.79	8.22	10.67	9.77
Crude cellulose,	30.35	30.40	31.46	30.24	30.32	30.23
Crude fat,	2.00	2.18	2.66	3.15	2.07	2.08
Crude protein,	14.65	14.86	13.34	12.61	16.48	15.82
Nitrogen-free extract matter,	43.03	43.60	43.75	45.78	40.46	42.10

Sulphate v. Muriate of Potash for Clovers. — This experiment with clovers was so carried out as to allow a careful comparison between the sulphate and the muriate as sources of potash for this crop, as well as the comparisons between varieties. A study of the figures giving yields shows that there seems to be no clearly defined difference in the effect of the two salts upon the total product. It is true that in the case of the alsike clover the muriate plat produced much the larger crop; but, since this was not the case with either of the other varieties, we are not justified in concluding that this difference is a direct consequence of the different manuring.

A study of the figures showing the composition of the crops from the several plats, however, reveals the fact that in every instance the percentage of nitrogen-free extract is greater in the hay raised on the sulphate of potash. It is true that the difference is not large, though in the case of the red clover it is sufficient to make a difference of rather over 140 pounds of this valuable class of nutrients in the product of one acre. It seems probable that this difference is due to the action of the chlorine of the muriate of potash in decreasing the formation of starch, — an effect which has often been noticed with the potato. Since, then, starch is one of the most valuable constituents of foods, it follows that the sulphate is to be preferred to the muriate of potash, if it can be obtained at the same price. This, however, has not thus far been the case. At prevailing prices, the muriate would seem likely to be the more profitably employed.

4. *Millets for Seed.*

The three species of Japanese millet reported in previous years have been again cultivated for seed. The product has been at the following rates per acre: barn-yard millet (*Panicum crus-galli*), straw, 6,554 pounds, seed, 57 bushels; Japanese panicle millet (*Panicum miliaceum*), straw, 5,514 pounds, seed, 26 bushels; common Japanese millet (*Panicum italicum*), straw, 5,017 pounds, seed, 53.3 bushels. The weights per bushel of the seed are respectively 35, 54 and 42 pounds. Owing to unfavorable weather, a large amount of the seed of the barn-yard millet wasted in the field, hence the yield appears smaller than it actually was.

5. *Millets for Fodder.*

(*a*) *First Experiment.* — Our three species of Japanese millets, viz., the " barn-yard," the " panicle " and the " common," have been carefully compared with each other and with Hungarian grass as fodder crops upon a somewhat extensive scale. Nearly one-half an acre of the barn-yard variety and one-third of an acre each of the others were sown. The soil was a rather heavy loam, which for several years has been manured only with fertilizers. On a part of each plat the fertilizers applied were bone meal, lime and double sulphate of potash and magnesia; on the balance of each, nitrate of soda, Thomas phosphatic slag and the double sulphate were applied. To Dr. Goessmann is left the discussion of the results of the two systems of manuring, as they were planned by him. We have here to do only with the comparison of the varieties under trial. Suffice it to say that the fertilizers were applied in only moderate amounts, and that they were spread after ploughing, and harrowed in. All varieties were sown on June 2, the seed covered with Breed's weeder and the land then rolled.

The following table shows the amount of seed sown, the date of cutting and the yield of well-cured hay. For convenience of comparison, the yield of the "barn-yard" variety is given for the same area as the others: —

Varieties of Millet (One-third Acre Each).

VARIETY.	Quantity of Seed sown (Quarts).	Date of Cutting.	Yield of Hay (Pounds).
Hungarian grass,	6½	Aug. 15,	1,730
Japanese common millet,	8	Aug. 26,	2,025
Japanese panicle millet,	8	Aug. 15,	2,410
Japanese barn-yard millet,	4⅓	Aug. 15,	2,603

The fact must be stated that the quantity of seed of the "barn-yard" variety proved to have been rather too great for a season so favorable for rank growth as was the last. The crop of this variety lodged badly, and was therefore cut rather before it would otherwise have been. It was the intention to cut each variety when the seed of the plants on the earliest portion of the plat was well formed, but before it began to harden; and this was done except in the case of the barn-yard variety, which, as before stated, was cut a little before this stage was reached. The several varieties yielded, as determined by calculation from the results given in the above table, at the following rates per acre of well-cured hay: Japanese barn-yard millet, 7,830 pounds; Japanese panicle millet, 7,230 pounds; Japanese common millet, 6,075 pounds; and Hungarian grass, 5,190 pounds.

(*b*) *Second Experiment.* — Seventeen varieties of millet, including the 4 above discussed, were given a trial upon a smaller scale, upon similar soil and under similar conditions to those just described. The plats in this experiment were ten rods long and one rod wide, containing, therefore, one-sixteenth of an acre each. The results are shown in the table which follows: —

Millets, Variety Tests (Plats One-sixteenth Acre Each).

	Quantity of Seed (Quarts).	Height of Plants (Inches).	Date of Cutting.	Yield of Hay (Pounds).
Canary bird seed,* . .	2	30	Aug. 25,	295
Early Harvest, . . .	2	36	Aug. 4,	325
Mukodamaski (Japanese),	2	42	Sept. 8,	540
Golden, . .	2	54	Sept. 8,	610
Golden Wonder, . .	2	48	Aug. 13,	480
Hokkaido (Japanese), .	2	47	Aug. 25,	430
Japanese common, .	2	48	Aug. 25,	475
Hungarian, .	2	39	Aug. 13,	550
Japanese white panicle, .	1½	78	Aug. 31,	840
Chinese. . . .	1½	51	Aug. 4,	460
Common broom corn, .	1½	40	July 28,	450
White French, . . .	1½	48	July 31,	310
Red French, . . .	1½	34	July 28,	300
Hog, ...	1½	37	July 28,	370
California, . . .	1½	37	July 28,	370
Japanese panicle, . .	1½	55	Aug. 15,	490
Japanese barn-yard, .	1	66	Aug. 13,	620

* In this table the names under which the varieties were advertised are used in the case of all purchased sorts. The Japanese varieties are of our own importation or production.

The varieties especially noteworthy for large production are the Japanese white panicle and the Japanese barn-yard, the latter not doing its best either in this trial or the other, on account of having been sown too thick. In estimating the significance of these results, this fact must be kept in mind. It is further important to state that the barn-yard variety is far less harsh and woody than any of the other large-growing varieties of millet. Its extreme succulence, however, makes it rather difficult to cure. We have had most success in handling it as clover is usually handled by the best farmers, viz., by curing mostly in the cock. It is our intention to publish analyses of these millets in a later report or bulletin.

Miscellaneous Crops.

A considerable number of miscellaneous crops have been under trial upon a small scale, or have been cultivated for illustrative purposes. Under this class may be included 37 species of grasses; 22 varieties of millet for seed; 26 species and varieties of leguminous fodder or green manuring crops; 7 varieties of oats; several varieties of sorghum recommended for fodder, — saccaline, iris, beggar weed and cystisus, all sent in for trial as fodder crops; Ankee grass and 2 varieties of sugar beets. Many of these require no especial notice, while most of the others can be sufficiently discussed in a few words.

The grasses include a considerable number of species, received through the kindness of Professor Fletcher of the Ontario Agricultural College, which are as yet entirely unknown to the general cultivator. Several among them are indigenous to America, and appear to possess qualities which fit them in an especial degree for our soil, climate and conditions, and must make them of great value in our agriculture. The seeds of all these grasses were sown last spring, and it therefore follows that they have not yet had a trial sufficiently long to warrant definite conclusions. Among those species, however, which, so far as can be judged from one season's growth, appear to be expressly promising, are the following: *Bromus schradeii*, *Bromus ciliatus*, *Agropyrum tenerum* and *Avena flavescens vera*. Seven indigenous species from seed collected in Amherst and vicinity are under trial, and two species were sent for trial by the United States Department of Agriculture. One of these, *Eragrostis New Mexicana*, appears promising; the other, *Elensine Egyptiaca*, gave one good cutting, but failed to start thereafter. If an annual, as this behavior indicates, it can hardly prove important.

The Millets. — Among the 22 varieties included in this trial are most of those cultivated as fodder crops, besides a few others which were of especial interest. In this trial all varieties were allowed to ripen seed. As it was, however, found impossible to prevent the birds from taking some of the seed, — a serious matter, where the quantities are small, — it is not deemed important to publish the figures showing yields.

It has been decided, after the experience of two years in cultivating these varieties both for fodder and for seed, *that there is no appreciable difference between the varieties sold by various seedsmen under the following names: White French, Chinese, broom corn and California.* This variety, as well as the French, red French and hog millets, are all apparently of the same species as the Japanese panicle millet, viz., *Panicum miliaceum*, and are all much inferior to the Japanese in productive capacity, and inferior, I believe, also, to Hungarian grass.

Leguminous Fodder and Green Manuring Crops.

Most of the species and varieties, 26 in number, coming under this class, have been named, described and commented upon in previous reports, and require no further mention at this time. Of a few it is necessary to speak briefly.

1. *Flat Pea* (*Lathyrus sylvestris*). — Of all the crops which have been urged upon the attention of the American farming public in recent years, few have been so highly praised as this. I am compelled to conclude, after three years' trial, and in view also of the experience of others, that it is not a crop which can prove valuable among us. The principal points against it are the following: —

(*a*) The seed germinates with extreme slowness and uncertainty, making this a difficult and expensive crop to start. It would hardly be possible to stock a field with it, except by starting the plants in a bed and then transplanting to the field.

(*b*) The plants are not perfectly hardy under average conditions.

(*c*) The plants in growing sprawl over the ground in such a manner as to make this a difficult crop to cut.

(*d*) The forage is not relished by cattle. This statement is based largely upon distinguished German authority.*

In conclusion, I may state that this crop does not appear to have made any important place for itself in the land of its origin, Germany.

2. "*Sweet Clover*" (*Melilotus alba*). — Two plats in Field B, each of one-tenth of an acre, were sown with this clover, as it was thought possible that it might prove useful for the silo or for green manuring. These plats are designated by numbers 10 and 11. Both received ground and steamed bone meal at the rate of 600 pounds per acre;

---

* Dr. Max Maercker and Dr. Julius Kuehn.

Plat 10, muriate of potash; and Plat 11, high-grade sulphate of potash, in both cases at the rate of 200 pounds per acre. The seed was sown at the rate of 3 pounds per plat. The plants were badly thrown out of the ground during the winter, but most of them survived. The growth, however, was poor, and both were cut June 19, yielding: Plat 11, 200 pounds; Plat 12, 285 pounds, green weight.

It was noticed that isolated plants or clumps of plants while growing had a much deeper shade of green, and were in many instances three times the average height of the other plants in the field. Examination revealed the fact that in every instance the roots of these plants were thickly set with the nodules characteristic of the Leguminosæ, while such nodules were either entirely or almost entirely absent from the roots of the feebler plants, which class included a large majority of those in the plats. It is believed that this difference accounts for the wide variation in the different plants. These nodules are due to the development upon the roots of specific bacteria (microscopic fungi). These bacteria must develop, like other plants, from seed; and this seed, when the culture of a new crop of this class is first begun in a given locality, is not present as a rule in such quantity as to insure a full development of the nodules. Such as do develop must come from spores which adhere to the seed of the new crop. In the case of a second or later crop the spores are more abundant, for, as is often the case with weed seeds, the few developed the first year, remaining in the soil with the roots of the crop, retain their vitality, and accordingly the crop does better when grown a second or third time than at first, because the more abundant spores cause a more abundant development of root nodules upon which the assimilation of free atmospheric nitrogen depends.

In this case sweet clover had never been grown upon these plats before; hence, as there were probably no spores in the soil, and nodules could come only from the few spores which happened to adhere to the seed sown, there were in the aggregate but few and the crop did poorly. The plats have been sown again with the same crop, in the expectation that in the second year of its culture it will do better. The probability that this will be the case should never be lost sight of when new leguminous crops are under trial.

3. *The Horse Bean (Vicia faba).* — This crop, so highly prized by Professor Robertson of Ontario, has been given a rather more extensive trial than most of the crops in this class during each of the last two years. It does not commend itself to my judgment as a fodder crop, for which it is recommended. It is subject to a blight, which often seriously injures it; it sets comparatively little seed, most of the blossoms blighting; and in yield it does not equal other leguminous crops which are more easily cultivated.

4. *Field Peas.* — During the past season we have tried three new varieties of field peas from Canada, all of which appear to be excellent sorts for field culture with oats or barley as fodder crops. There does not appear to be a very wide difference between the three in productive capacity. All were remarkably free from mildew. The table below gives all information necessary for a comparative estimate of these varieties: —

Field Peas (2 Rows, Each 70 Feet Long).

	English Gray.	Canada Beauty.	Prussian Blue.
	Pounds.	Pounds.	Pounds.
Total yield, pods filled but vines still green,	165	200	205
	Per Cent.	Per Cent.	Per Cent.
Dry matter,	14.77	18.28	18.06
Water,	85.23	81.72	81.94
	100.00	100.00	100.00
Dry matter contains: —			
Crude ash,	9.56	7.80	–
Crude cellulose,	30.23	28.99	–
Crude fat,	3.16	2.74	–
Crude protein,	20.65	16.14	–
Nitrogen-free extract,	36.40	44.33	–
	100.00	100.00	–

It is noticeable that the first variety is considerably richer in protein than the others; but, as the yield is so much smaller, either of the latter would seem to be preferable as fodder crops. They not only yield more heavily, but the fodder contains a considerably larger percentage of dry matter, which gives them greater food value. It might be thought that the Canada Beauty and Prussian Blue must have been more mature than the others, but this is not believed to have been the case. The effort was to harvest each in the same stage of maturity. Moreover, all were planted on the same date, May 2, and they were harvested as follows: English Gray, July 11; Canada Beauty, July 14; and Prussian Blue, July 2.

Oats. — Five varieties of *common oats* were tried upon a small scale, chiefly with a view to determining whether a variety could be found capable, under our peculiar climatic and soil conditions, of resisting rust. The attempt was a failure so far as this particular object is concerned, as all varieties rusted, and apparently to practically the same extent. The crop, however, was a fairly good one. The area occupied by each variety was 7 by 85 feet (one seventy-third of an acre). The yield is shown below: —

Varieties of Oats (One Seventy-third Acre Each).

	Straw (Pounds).	Grain (Pounds).	Weight per Bushel (Pounds).
Siberian,	57	30	32
Lincoln,	52	34	31
Black Beauty,	66	35	29½
New Illinois,	59	32	30½
White Poland,	52	27	33

A yield of 31 pounds is almost exactly at the rate of 70 bushels of 32 pounds each per acre.

Winter Oats. — Two varieties of winter oats have been tried during the past year. The seed of one sort was obtained from Dover, Del., of the other from Charlottesville, Va. In both of these States winter oats are considerably cultivated, and, as the impression there seemed to be that these oats are quite hardy, it was decided to try them. We were also invited by Peter Henderson & Co. to make such a trial. One plat of one-tenth of an acre in rather heavy but well-drained loam and another of about three-eighths of an acre in medium loam were selected for the experiment. The seed was sown in drills about the last of September, and the oats had made a good start before cold weather. *Not a single plant survived the winter in either plat.*

Sorghum Varieties. — Several varieties of reputed fodder plants belonging to the genus *Sorghum* have been under trial in a small way during each of the last few years, usually at the suggestion of the United States Department of Agriculture. It is believed by some of the officers of this department that plants of this class, having greater capacity to resist drought than many others, will prove valuable fodder plants; and this opinion is seemingly justified by the results of trials in some of the western States. In Kansas, indeed, very favorable results have been obtained with some of them as grain crops. Such of these crops as have been tried here have always been put in warm, well-drained soil, but they have in no instance equalled Indian corn as fodder crops. Those tried this year are the following: "Jerusalem corn," "Red Kaffir corn," "White Kaffir corn" and "Millo maize." "Teosinte," although not a sorghum, can be considered with them. All of these grow very slowly at first, which increases the cost of culture largely, as compared with corn. None of them have ripened seed with us. *For the various reasons above stated, I do not regard any of these crops as likely to prove valuable for Massachusetts farmers.*

Saccaline. — Seed obtained in 1895 was started in a bed in the open air, and in midsummer plants were set in two plats, one in light sandy soil, the other in a heavy moist soil. The plants in the latter grew vigorously until late fall, those in the sandy soil but feebly. During the winter about 75 per cent. of the plants in both plats were killed. A similar proportion of plants temporarily set in a bed in medium loam died during the winter. Such plants as survived the winter in the moist soil made a very early start in the spring, but were entirely destroyed by later frosts. I judge that the plant is far from being sufficiently hardy for our climate. Moreover, it is not much relished by stock unless cut very young. Further, it should be remembered, by any one trying it in a locality where it thrives, that it spreads rapidly by means of underground stems, and that it is extremely difficult to eradicate when once it has gained possession of the ground.

Iris pabularia. — Seeds were sent for trial by J. M. Thorburn & Co. of New York in 1895, the statement being made that it might prove valuable as a fodder crop. Germination was slow, the plants grew but feebly and during last winter all were killed.

Cystisus proliferus albus. — Seeds were received for trial of this plant as a fodder crop in the spring of 1895. Germination was imperfect, the plants did not make much growth and all died during last winter.

Florida Beggar Weed (*Desmodium tortuosum*). — Seeds sent for trial as a possibly valuable fodder crop were sown May 4. The plants grew to be about 3 feet tall, with numerous branches and leaves, which are eaten by stock. The main stem is hard and woody. The amount of fodder produced does not equal that produced by the soya bean in the same time. The plants did not reach the blossoming stage and were killed to the ground by the first frost. I judge that it will have no value here as a fodder plant.

Spurry (*Spergula arvensis*). — Two varieties, "small" and "giant," were under trial on a small scale. Neither produced fodder enough to make it of value.

Ankee Grass (*Panicum crus-galli*). — Seed of a variety of this species (the same as that to which our Japanese barnyard millet belongs) was received from the United States Department of Agriculture, with the request that we submit it to trial. It was stated that it had been collected by C. R. Orcutt, and that the seed was used as food by the Indians of South California and Arizona. The seed was sown May 4, and the crop was given careful culture. The plants grew about 5 feet tall, the stems were coarse, harsh and woody, brown in color, quite leafy. Panicles open like those of the common weed (barn-yard grass), but without awns, large. Seeds did not ripen. As compared with the Japanese barnyard millet, this variety is not as tall, coarser and more woody and much later. It is decidedly inferior to the Japanese variety in every respect as a fodder crop for this locality. It is quite probable, however, considering its origin, that the Ankee grass will endure drought better than the Japanese barn-yard millet.

Millets under False Names. — The reputation of some of our Japanese millets is such that seed has for the last two years been offered in some quarters which is not genuine. We have received and tested three such samples, from widely different sources. In one of these cases the mistake may have been inadvertent. The variety was sold as Japanese barn-yard millet; it proved to be the Japanese panicle millet, — a widely different sort. *It should be remembered that we have sent out three Japanese millets, viz., the barn-yard, panicle and common. The first we consider to be the most valuable as a fodder crop.*

SULPHATE OF IRON AS A FERTILIZER.

A recent English work on manures and fertilizers* lays great stress upon the value of *sulphate of iron* as a fertilizer, and contains figures giving the results of many apparently careful experiments, all tending to show that this chemical often has a considerable influence in increasing crops. The opinions of Mr. Griffiths upon this point, so far as I am aware, are not shared by most authorities, and I had not much confidence that experiments here would give results similar to those he reports. Still, it is our place to put such questions to the test. Accordingly a piece of land that for some years has been manured yearly at the rate of 600 pounds ground bone and 200 pounds muriate of potash per acre, and which has produced a variety of crops, including grass, potatoes and clover, was selected for the purpose. It was divided into four plats, and all received the customary application of bone and potash, applied in September, 1895. These plats contain one-thirtieth of an acre each. The crop was the medium green soya bean, planted June 13. Sulphate of iron was applied to two of these plats, Nos. 1 and 4, on June 24, just as the beans were coming up, at the rate of 80 pounds per acre.

---

* Griffiths, "Farm Manures."

It has been claimed by Griffiths that the use of this salt favors chlorophyll formation, and that it therefore causes a perceptibly deeper shade of green in the leaves in the plants to which it is applied. No difference could be detected during the season. The average crop (cut green for the silo) where the sulphate of iron was applied was 462½ pounds, the average of the other plats 445 pounds, — a difference of 17½ pounds in favor of the treatment, or at the rate of 525 pounds per acre. I consider this difference too small to be of much significance.

"Bug Death."

This is a preparation sent to us by the Danforth Chemical Company, Leominster, Mass., as a substitute for Paris green as a poison for potato bugs and as a preventive of blight. It was received late in the season, the "bugs" being full grown when we were able to use it the first time. It kills them, but not as quickly as Paris green; and as, in showery weather particularly, rapidity of action is desirable, I do not look upon it as equal in value to that poison for this and similar purposes. The "Bug Death" had no apparent effect in preventing blight.

Atomizer for applying the Bug Death.

The Danforth Chemical Company sent with the "Bug Death" a large atomizer, which they recommended for its application. This material and similar dry poisons can be applied with this atomizer, but it is entirely unsuited to use upon a large scale. The hand soon becomes excessively and painfully weary from the motion required, while the time occupied is far greater than by other means which are within the reach of all. It required twenty-eight minutes to cover a row with the atomizer, while the same length of row was covered by the use of Leggett's gun in eight minutes.

Fungiroid.

"Fungiroid," sold by the manufacturers of Leggett's dry insect powder gun as a means of preventing potato blight, has been given a thorough trial. Both the "*Fungiroid" in combination with Paris green*, furnished and recommended by the company, and in the latter part of the season, when the bugs had ceased to be troublesome, the *pure* "*Fungiroid*," were employed. The season was hot, with frequent showers, furnishing, therefore, conditions highly favorable to the development of parasitic fungi, and extremely unfavorable to the action of the "Fungiroid." It was, however, reapplied at frequent intervals, and always after a heavy rain and while the vines were moist.

The treatment was applied to one row each of the 60 varieties in our variety test. One row each of 38 of these varieties, in an adjoining plat, upon similar soil and grown under precisely similar conditions, was left untreated. No difference whatever could be detected in the extent to which blight affected the treated and untreated vines. "*Fungiroid*" *and Paris green mixture* (prepared) was applied at the rate of 2 pounds per acre to the vines of the treated plat with Leggett's gun, and in accordance with directions, on each of the following dates: July 13, 18, 22 and 24. Pure "Fungiroid" was applied twice, at the rate of 1½ pounds per acre, and in the same manner, on August 1 and 3. By the latter date blight had affected all varieties in the plat and to a considerable extent in most cases. The yield from 38 rows treated as described was 7,887½ pounds of large and 983 pounds of small potatoes. The 38 rows which were untreated produced 8,407 pounds of large and 960 pounds of small tubers. The results surely indicate no favorable influence due to the use of "Fungiroid."

SCAB OF POTATOES.

It has been thought by some experimenters that, by an application of sulphur at the time of planting, "scab" of potatoes, even in infected soil, could be prevented. Accordingly, as we had such an infected soil where a very scabby crop was raised last season, it was decided to test this point. The plan of the experiment was as follows: one-half the seed required was treated with corrosive sublimate solution in the usual way; then 240 hills were planted with each kind of seed (treated and untreated), and in the furrow with one-half of these hills sulphur at the rate of 300 pounds per acre was scattered at time of planting. The table below shows the results: —

Sulphur for Prevention of Scab of Potatoes (120 Hills Each).

TREATMENT.		LARGE TUBERS.			Small Tubers.
		Free of Scab (Pounds).	Slightly Scabby (Pounds).	Badly Scabby (Pounds).	
Seed treated with corrosive sublimate,	no sulphur,	21	78½	48	24
	sulphur,	2	80½	56	15
Seed untreated,	no sulphur,	2 tubers	70½	84½	19½
	sulphur,	3 tubers	67	96	20

The use of sulphur in the drill appears to have been absolutely without effect. The table indicates that even when seed is planted in infected land the treatment with corrosive sublimate is somewhat beneficial.

TRIAL OF HAY CAPS.

Another season's use, and very frequent and extended use, of the three styles of hay caps mentioned in my last report, viz., the Symmes' paper board, oiled cotton and cotton impregnated with tannin, has led to the following conclusions: —

1. Caps of some sort are extremely useful, especially with such crops as clover, millets, oats and peas, and other slow-curing crops, especially those much injured by excessive handling.

2. The Symmes' cap is most quickly applied, — an important point, — and is best liked. It appears to be wearing very well.

3. Of the two styles of cloth caps in use, those impregnated with tannin are most durable. The oiled caps are more mildewed than the others and have become much more torn.

4. It has been found that in some cases, where clover has been cocked quite green and covered with the three kinds of caps and allowed to stand for some time with frequent rains, it has kept better under the cloth than under the Symmes' caps. The porosity of the former in such cases appears to be an advantage.

Poultry Experiments.

Poultry experiments were continued during the winter of 1895–96 upon a small scale. Our attention has been confined to two points, viz.: —

1. Effect upon egg-production of the use of condition powders.

2. Comparative value for egg-production of dry ground animal meal and cut fresh bone.

1. Effect of Condition Powder upon Egg-production.

The experiment to test the value of condition powder in feeding for eggs was begun February 9 and continued until April 28. We used two lots of fowls, selected with the utmost care with respect to similar characteristics in the two lots. Each lot contained 3 barred Plymouth Rock hens, 8 light Brahma hens, 6 light Brahma pullets and 2 Wyandotte-light Brahma pullets. The hens were one and three-quarters years old at the time the experiment began. Each lot, consisting of 19 fowls, occupied a detached house having two compartments (scratching shed and closed roosting and nest room), respectively 8 by 12 and 10 by 12 feet in size, the nest room with two windows. These houses adjoin each other and both have precisely the same exposure. The two lots were fed as follows: in the morning they received a mash which was mixed hot the previous evening; at noon, and again one hour before sundown, whole grain was scattered in the straw in the scratching sheds. Artificial grit, oyster shells and pure water were kept always before them. The only difference in the management of the two lots was that condition powder was mixed in the mash for one lot, in accordance with directions furnished with the powder. This experiment seemed important, in view of the large amount of money, in the aggregate, which is expended in the purchase of such powders; and, notwithstanding the very general impression that they are useful, in the absence of any definite proof of the fact. *I would call especial attention to the fact, — which, though generally well known, is often lost sight of, — that no one experiment can settle this question in the one way or the other.* The results of this experiment are published, then, not as settling the question, but simply as evidence bearing upon an important point, to be accepted only for what it may be worth.

The foods used in this experiment and in the other described later, and their composition, are shown below : —

Composition of Air-dry Foods used in Poultry Experiments (Parts in 100).

	Water.	Crude Ash.	Crude Cellulose.	Crude Fat.	Crude Protein.	Nitrogen-free Extract.
Ground clover, ...	9.53	7.43	27.80	1.93	13.65	39.66
Wheat bran, ...	9.56	5.27	8.85	5.37	17.69	53.26
Animal meal, . . .	5.08	28.63	–	16.18	40.03	10.08
Cut bone, ...	29.67	24.06	–	26.13	20.19	–
New-process linseed meal, .	9.35	4.48	6.58	6.39	38.06	35.14
Buffalo gluten meal, . .	7.14	.84	7.07	12.67	23.31	48.97
Chicago gluten meal, . .	8.10	.83	3.34	5.57	36.51	45.65
Wheat middlings, . .	10.93	4.03	6.95	5.30	17.28	55.51
Whole wheat, . . .	10.60	1.69	2.17	1.93	13.19	70.42
Whole oats, ...	10.06	2.77	8.71	4.87	14.53	59.06
Soya-bean meal, . . .	9.24	5.02	3.87	16.25	34.75	30.87

The kinds and total amounts of the several foods used in this experiment for the lot of fowls having condition powders are as follows (in pounds) : whole wheat, 100 ; whole oats, 99.5 ; wheat bran, 19.8 ; wheat middlings, 19.8 ; ground clover, 19.8 ; new-process linseed meal, 9.9 ; animal meal, 9.9 ; soya-bean meal, 9.9 ; cut bones, 3. Two pounds of condition powder were used. All the meals, bran, middlings, ground clover and bones were given in the form of the morning mash. The total number of pounds of food used was 291.6. The nutritive ratio, based upon composition (as digestibility by fowls is not known), is 1 : 4.5. The cost of all the food used was $3.43, not including the condition powder.

The lot of fowls which received no condition powder received foods as follows (in pounds) : whole wheat, 99.5 ; whole oats, 100 ; wheat bran, 19.3 ; wheat middlings, 19.3 ; ground clover, 19.3 ; new-process linseed meal, 9.7 ; animal meal, 9.7; soya-bean meal, 9.7; and cut bone, 3. Total number of pounds, 289.5; total cost, $3.39; nutritive ratio, 1:4.5.

The results and leading details of the experiment are shown in the table below: —

Condition Powders for Egg-production.

Experiment, February 9 to April 28.	Duration of Experiment.	Total Food consumed.	Cost of Food per Day per Fowl.	Number Eggs produced.	Dry Matter in Food per Egg.	Cost of Food per Egg.
	Days.	Pounds.	Cents.		Pounds.	Cents.
19 fowls, condition powder,	79	291.6	.23	163	1.611	2.1
19 fowls, no condition powder,		289.5	.23	195	1.333	1.8

In the above estimate the cost of the condition powder is not included. This amounts to $1, which would make the cost per egg 2.7 cents in the case of the fowls receiving it.

The fowls receiving no condition powder laid their first egg on February 12; those receiving it, their first egg on March 16, at which time the other lot had laid 24 eggs. One hen in each lot died during the experiment. At its close the fowls in both lots appeared to be in about equal condition of health, but two in the condition-powder lot had begun to moult, while there were no indications of moulting in the other lot. There was no material difference in the size or appearance of the eggs from the two lots. This experiment is now being repeated, with lots of pullets most carefully selected with reference to it, having been begun on Jan. 1, 1897.

2. *Animal Meal v. Cut Bone for Egg-production.*

The general conditions of this experiment were similar to those in the experiment to test the value of condition powder. Each house contained 2 barred Plymouth Rock and 10 light Brahma hens, 5 light Brahma pullets and 2 white Wyandotte-light Brahma pullets; total, 19 fowls. The experiment began February 9 and ended April 28.

The food received by the lot having cut bone was as follows (in pounds); whole wheat, 99.5; oats, 100; wheat bran, 18.5; wheat middlings, 18.5; Chicago gluten meal, 18.5; ground clover, 18.5; cut bone, 10; total, 283.5 pounds; cost, $3.25; nutritive ratio, 1 : 4.8.

The other lot received essentially the same foods, except that in place of the bone it got 9.7 pounds of animal meal; total food, 287 pounds; cost, $3.26; nutritive ratio, 1 : 4.9.

The leading details and results are shown in the following table: —

Cut Bone v. Animal Meal for Egg-production.

BEGAN FEBRUARY 9, ENDED APRIL 28.	Duration of Experiment.	Total Food consumed.	Cost of Food per Fowl daily.	Number of Eggs produced.	Dry Matter in Food per Egg.	Cost of Food per Egg.
	Days.	Pounds.	Cents.		Pounds.	Cents.
Cut bone lot,	79	283.5	.22	269	.940	1.2
Animal meal lot,		287.0	.22	145*	1.796	2.2

* One soft shelled.

In the above estimate of cost the labor required to cut the bones is included. The results indicate a decided advantage in favor of the bone. During last year two experiments were tried, one of which resulted favorably to the bone, the other to the animal meal. Last year there was some diarrhœa among the fowls having bone, this being given alone. This year the bone was fed in the mash, and there has been no such trouble. There has been this year no perceptible difference either in the condition of the fowls in the two lots or in the size or character of the eggs produced. The experiment indicates, then, a decided advantage in favor of the cut bone. This experiment is now being repeated.

REPORT OF THE METEOROLOGIST.

LEONARD METCALF.

During the past year the usual meteorological observations have been continued, and the results have been compiled with those of previous years. A special bulletin will be published with the annual summary of observations for the year 1896, in January, 1897, giving the mean annual and the maximum and minimum records for this station for the past eight years, *i.e.*, since the equipment of our observatory.

The advisability of making a change in the time and frequency of taking the observations, from tri-daily readings at 7 A.M., 2 P.M. and 9 P.M., to bi-daily readings at 8 A.M. and 8 P.M., to conform with the present method of the U. S. Weather Bureau, was considered; but, after discussing the subject thoroughly with the department at Boston and at Washington, it was deemed unwise to make the change, and the observations have therefore been taken three times a day, as heretofore.

After a careful study of the thermometer records of the tower shelter, it was found that the local conditions of exposure were such as to seriously affect the accuracy of the temperature readings, and the Draper thermograph, by which the mean daily air temperature at the tower was found, was removed to the ground shelter, where its readings are checked and corrected three times a day by a standard mercury thermometer and by the maximum and minimum thermometers previously kept there. While record is still kept of the maximum and minimum air temperatures in the tower shelter, it is no longer published. The wet and dry bulb thermometers were also removed to the ground shelter, and the wet-bulb reading or "sensible temperature" of the air is now published, as well as the dry-bulb reading. This "sensible temperature" is of course the temperature of the atmosphere as we ordinarily feel it, as the sensible temperature is directly dependent upon the relative humidity of the air, and hence upon the cooling effect of the evaporation of the surface moisture.

After a careful comparison of the rainfall records of the ground and the tower, obtained in each case by United States Weather Bureau rain gauge, it was found that the tower records were so affected by upward wind currents, due to the shape of the roof, as to render them of very doubtful value. The tower "precipitation" observations have therefore been discontinued.

Some additional records have been kept during the past year and will be continued this year. Among these are the number of days of sleighing and the amount of snow on the ground at the beginning of each week, the latter being reported to the New England Weather Bureau weekly. Record has also been kept of the accuracy of the forecasts received daily at this station; this record shows that, while the monthly percentage of correct forecasts has varied from 69 per cent. to 90 per cent. during the year, the mean percentage of accuracy of forecasts has been 78 per cent.

A few new instruments have been added to the station's equipment: two sets of Green maximum and minimum thermometers; six mercury thermometers, United States Signal Service pattern, made by Green; and a thermophone,* with four resistance temperature coils, made by E. S. Ritchie & Sons, the latter instruments being intended for experiments on soil temperatures.

Through the courtesy of Professor Whitney, one of his assistants, Mr. Thomas H. Means of the Division of Soils, Department of Agriculture, was sent to Amherst in the middle of July to install a set of Professor Whitney's apparatus for the determination of soil temperature and moisture. Soil-temperature electrodes and moisture-resistance plates were buried in grass land, a short distance from the ground shelter, at five different depths, from the surface of the ground to a depth of two feet; and from that time, the middle of

---

* The thermophone was recently designed and patented by Messrs. Henry E. Warren and George C. Whipple.

July, until the latter part of August, when the reading instrument broke down, daily records of the soil temperature and moisture were taken. The reading instrument above referred to was designed by Professor Whitney, and is a form of Wheatstone's bridge, reading the electrical resistance of the temperature cell and of the soil itself, from which data the temperature and moisture of the soil are computed.

Early in September the thermophone was received from Messrs. Ritchie & Sons, and its temperature-resistance coils were buried not far from the Whitney apparatus, at depths of three, twelve, twenty-four and thirty-six inches respectively. On this have been taken tri-daily soil temperature observations to the present time, and these records will be continued throughout the winter, the results being plotted each month, at its close, for purposes of comparison.

In the spring the thermometer coils will probably be taken up and put down in another place for observations, together with other instruments, on soil and air temperatures on an experimental corn plot; as plans have been formulated in co-operation with Doctors Allen, True and Whitney of the Department of Agriculture at Washington, and considerable work has been done preliminary to undertaking at Amherst a series of experiments bearing upon soil temperatures and moistures in their relation to the growth and advancement of crops.

REPORT OF THE HORTICULTURIST.

SAMUEL T. MAYNARD.

The number of varieties of fruits tested during the past season has been greatly increased, and the testing of a large number of varieties of vegetable seeds has been added to the work.

A large addition of varieties of apples, Japanese plums, peaches, cherries and the new species of raspberries and blackberries has been made by purchase of young stock, or by budding or grafting into stocks already established.

Spraying.

The protection of fruit and garden crops from insects and fungous pests has formed an important part of the work of this division, the results of which again emphasize the fact that good fruit cannot be grown without more or less use of insecticides and fungicides. The most approved apparatus and the new methods of application, as well as the new insecticides and fungicides, are given a very careful trial as soon after their introduction as possible.

The insecticides most used are Paris green, kerosene emulsion, hellebore and pyrethum or insect powder. In the greenhouses lemon oil has proved the most valuable substance for keeping down scale and mealy bugs.

The fungicides most used are copper sulphate solutions, Bordeaux mixture and ammoniacal carbonate of copper.

Dry Bordeaux Mixture.

During the winter and spring many inquiries as to the value of the dry Bordeaux mixture and methods of manufacture were received, and several parties began its manufacture and put it on the market. Many samples were sent us for trial, and the results of the tests were carefully noted. As far as can be determined from one season's trial, the results have *not* been satisfactory, for the following reasons: first, that the material is not in sufficiently fine condition; second, that it is impossible to make it adhere for any considerable time to the foliage or other parts of the plants even when applied to a wet surface; third, that there is a great waste of material, much of it falling to the ground. After careful investigation, we have not noticed any marked beneficial result following its use. For the above reasons, the dry Bordeaux mixture does not appear to be as efficient as that in a liquid form.

Steam Spraying Outfit.

One of the greatest obstacles to the use of insect and fungi destroyers has been the difficulty of obtaining pumps of sufficient power to enable the application of liquids to be made thoroughly, as fast as an ordinary team would move along among trees or garden crops; and a careful trial of a steam spraying outfit has been one of the features of the past season's work. As the result of repeated trial, we feel warranted in the assertion that, when run with care and skill, very satisfactory work can be done better and more cheaply than when done by hand or by the gear machines. It is of course understood that the manipulator must be thoroughly acquainted with the construction of the engine and pump, and be skilful in keeping all parts in perfect working order. The cost of such spraying outfits, of which several are now offered in the market, and ranging in price from $200 to $400, is much against its use by the small farmer or fruit grower; but in almost every village or town the work of spraying for a large number of individuals by the single owner of an outfit could be done at a less cost than if each person were to equip himself with small and imperfectly working pumps. This would probably be found more satisfactory than if the outfit were owned by a number of individuals. A steam engine suitable for this work, and fitted with a fly wheel, so that the power could be utilized, when not needed for spraying, for cutting wood, corn fodder or ensilage, grinding grain, pumping water for stock or irrigation, would be a source of profit in many directions.

SEED TESTING.

Complaints having been frequently received affecting the germinating qualities of seeds and vegetables and their purity, coupled with requests for examination and testing of the same, an extended investigation was undertaken of seeds of standard varieties from prominent dealers in different sections of the country. In all, 367 different packages of seeds were tested, each variety involving four distinct tests. These were obtained from seven of the leading seed dealers, as follows: 4 from Massachusetts, 1 from New York City, 1 from Philadelphia, Pa., and 1 from Detroit, Mich. The number of varieties tested was: beets, 4 (28 packages);* cabbage, 5 (35 packages); cauliflower, 3 (21 packages); celery, 5 (30 packages); cucumbers, 4 (28 packages); lettuce, 7 (27 packages); melons, 5 (23 packages); onions, 5 (30 packages); parsnips, 9 (18 packages); peas, 4 (28 packages); radishes, 6 (24 packages); spinach, 8 (19 packages); squashes, 4 (28 packages); tomatoes, 4 (28 packages).

These seeds were first tested for their germinating qualities by two different methods under glass. These were also noted when planted in the field, and careful observations made and recorded from time to time as to vigor of growth. At the end of the season the characteristics of foliage and products were carefully determined, and the crop of each strain weighed. Each kind of vegetable was planted in soil best suited to its growth, and the seeds from each dealer given the same treatment in every way.

Results.

We are glad to report that with one or two exceptions the vitality (germinating qualities) of the seeds was very satisfactory, about the same per cent. of seeds of each kind from the different dealers germinating, and the products were generally uniform in outline and markings. The varieties sold by the different dealers under the same name generally proved to possess the same characteristics.

---

* The same varieties, from 7 different dealers.

With the experience gained in this work the past season it is hoped another year that, in addition to similar tests, seeds may be collected from the stock kept on sale in country stores, much of which is produced by growers of little skill, and possibly in localities where mixing by cross-fertilization cannot be avoided. This will entail a large amount of work, a considerable addition to the area of land occupied and much greater expense.

The complete results of the season's test will be presented in tabulated form in a later bulletin.

REPORT OF THE BOTANISTS.

GEORGE E. STONE, RALPH E. SMITH.

The work of this department has followed the plan outlined in the last annual report. Much of our attention during the past year has been devoted to the study of the gall-forming nematode worms affecting cucumbers and tomatoes grown under glass, in the hope of finding some effectual method of combating them. Professor Smith has devoted considerable attention to the study of their life history. The results of the investigations, when completed, will be published in a bulletin.

Most of the correspondence of the department has had reference to plant diseases, although during the summer many inquiries have been received regarding weeds. For the purpose of facilitating their study, we have collected during the past summer about two hundred and fifty species for the herbarium, including several species which have been recently introduced in grass and other kinds of seed. The department takes this opportunity of soliciting correspondence on this subject, as it is desirous of obtaining information in regard to the introduction and distribution of weeds and other plants which may possibly become troublesome.

The Nature of Plant Diseases.

Before passing on to a consideration of some of the plant diseases which have occupied our attention during the past year, it will be well to pay some attention to the nature of plant diseases in general. The diseases with which botanists have to deal can be divided into two classes, namely: first, those which are caused by parasitic fungi, bacteria and similar organisms; and second, those brought about by purely physiological disorders, which have their origin in some abnormal condition of the plant, due to improper care and surroundings. While the distinction between the two classes of disorders can in many cases be readily discerned, in other cases it is indeed difficult to discriminate between them, as physiological disorders of the plant so frequently produce just the conditions which are most favorable for the development of parasitic fungi and bacteria. Thus the original cause of the trouble is liable to be entirely lost sight of. Bearing in mind this fact, it must be clear that to recommend fungicides for the treatment of physiological diseases is about as absurd as it would be for a physician to treat a person for consumption who was suffering from malaria or indigestion, and simply required a change in his food or the conditions which surrounded him. The only logical method of treatment under such circumstances is to restore the normal and proper conditions. On the other hand, parasitic fungi which cause serious disorders in our cultivated plants are also found on plants which would pass for quite normal and healthy ones. In fact, probably no plant is entirely exempt from parasites; and here we are brought face to face with the question, What constitutes a plant disease? It may be defined as a disorder caused by any failing in or diversion of the normal physiological actions of the plant. Practically, we include as plant diseases the effects of all of those forms of parasitic fungi which occur on plants, although it is doubtful whether many of them really cause any perceptible harm to their hosts.

Of the two classes of diseases, the parasitic and physiological, those of the latter are more likely to be prevalent in greenhouse plants, inasmuch as the conditions to which the latter are subjected are very artificial, and cannot coincide very closely with those of their normal habitat. The physiological disorders, moreover, are much less likely to be discerned, and, when found, are more difficult to contend with than parasitic attacks, for they are more complicated in their nature, as well as less thoroughly understood. In all our dealings with the plant we must bear in mind that it is a plastic organism, capable of responding, within certain limits, to a great variety of external factors which act as stimuli. These external stimuli are principally to be found in heat, light, moisture and in the soil conditions. It is therefore the proper application of these factors which the practical grower has to take into consideration, and his success in plant growing will depend largely upon his skill in dealing with them. The minute details connected with the application of light, heat and moisture, the judicious use of fertilizers and the bringing of the soil into proper mechanical condition, are matters which are now commencing to receive some of the attention which they deserve.

DISEASES ENTIRELY OR PARTIALLY DUE TO PARASITIC ORGANISMS.

A Bacterial Disease of the Strawberry (*Micrococcus* sp.?).

During a hot sultry period which occurred in the month of May, 1895, some diseased strawberry plants of the varieties known as the Sharpless and the Belmont were sent to the botanical department from Fitchburg, Mass., for the purpose of determining the nature of the disease and the remedies for the same. The freshly gathered plants showed by their dark-colored, shrivelled leaves that they had been killed outright in the field by some unknown cause.

A careful microscopic examination of the plant proved that there was nothing of an insect or fungous nature to which the trouble could be attributed; but by making more careful observations of the cell contents of the roots and leaf petioles, numerous bacteria (micrococci) were found, which at least indicated a possible cause of the disease.

At about the same time these specimens were received, the disease made its appearance on many of the strawberry plants in the college plats, resulting fatally to the plants in numerous instances, besides leaving others in a dilapidated condition. The variety which suffered the most in the college plats was the Marshall.

In order to ascertain whether the two diseases were identical, and whether the bacteria were the specific cause of the disorder, the organisms were isolated, and a number of pure cultures made in the ordinary sterilized nutrient gelatine. In this medium the bacteria developed quite readily, producing a white, flocculent mass at the bottom of the tube. Its manner of growth in gelatine proved it to be of an anærobic * nature. From time to time the organism was transferred to fresh gelatine; and during the next fall three varieties of strawberry plants, including the Marshall, Belmont and Sharpless, were transplanted to the greenhouse. After the new plants, which were not especially robust, had made some growth, they were placed in a warm, humid atmosphere, and the roots of a number of plants of each variety were inoculated with the pure cultures of bacteria from the gelatine tubes. As a result of the inoculation, the plants after a few days showed the effects of the disease, some, however, more than others; but in all cases the disease was somewhat milder than in the plants originally affected. An examination of the affected parts of the plant showed the same bacterium, and cultures made from the petioles and roots gave the same characteristic micrococci. Other strawberry plants were again inoculated with the new isolated forms, with corresponding results.

No further experiments in this direction were considered necessary, inasmuch as the effects of the bacteria upon the plants had been ascertained. I will state here, however, that I had never seen the disease previous to this, neither have I been able to detect it since. I consider it one of those sporadic afflictions with which any plant is likely to be troubled, provided just the right conditions are at hand. In this instance the conditions of the weather and that of the plant were especially favorable for such an attack. All of the plants under examination were young, and had not been transplanted a great while; and, furthermore, they had all the appearances of plants which had not become firmly established in the soil. The organism is, not unlikely, a common form of micrococcus which under peculiar conditions is liable to cause some injury. Inasmuch as the primary cause of the disease has its origin in a weakened condition of the plant, and inasmuch as there is every reason to believe that the organism gains its entrance through the root, any attempt to apply fungicides would be useless. The only practical method of dealing with a difficulty of this kind, should it occasionally make its appearance, is to take more pains in

---

* Not requiring free oxygen.

securing a rugged stock and to keep a more watchful care over the plants during their critical period of transplanting, thus rendering them less susceptible.

A Stem Rot of the Cultivated Aster.

My attention was first called to this disease during the fall of 1895, while visiting the florist, Mr. L. W. Goodell of Pansy Park, who raises a large variety of asters for seed. The specimens obtained from Mr. Goodell were gathered rather late in the fall, when the disease was far advanced, being characterized at this stage of its development by a general blackened and shrivelled condition of the whole plant. Closer observation of the specimen, however, located the point of attack on the stem, close to the root, where the epidermal tissues which surrounded the abnormally hardened wood were more or less disintegrated.

A microscopic examination of the tissues of the affected parts showed a variety of organisms, such as bacteria (micrococci), nematode worms, and such mould-like fungi as Alternaria, Macrosporium and Physarium. Some of these organisms alone might give rise to the disease, but it is more probable that most of them were merely accompanying factors of the diseased conditions to which the plants were subjected.

The bacteria and nematode worms were by far the most abundant, the bacteria especially being widely distributed through the tissues, on that part of the stem adjacent to the roots. Owing to the fact that all of the material at our disposal was in too advanced a stage, it was impossible to arrive at any definite conclusion in regard to the cause of the disease. Since examining the specimen obtained from Mr. Goodell we have heard of the disease as occurring in other places. Among them may be mentioned Mr. Joseph Ammer of Springfield, who writes us as follows: —

Dear Sir: — In reply to your favor of September 21, I am sorry to say that I cannot send you a specimen of the aster plants, because they are all past. The plants appeared to be in a good and vigorous condition up to the time of setting flower beds, when they began to wilt very rapidly, and in a little more than a week a whole bed of seventy-five or one hundred plants was nearly if not quite gone, save perhaps eight or ten. On closer examination I found that the stock right at the surface of the soil for about an inch appeared soft and pulpy and could be scraped away to the hard heart, which in most cases was black and dead. I could not account for it in any way, unless it was some fungous disease.

There are many others around here who are troubled the same way; some called it lice on the roots, others "aster blight," and let it go at that. The varieties most affected were "Queen of the Market," "Victoria" and the "Comet," while the new "Giant White Comet" was entirely free from it, although separated from the worst bed only by a four-foot path.

If you can suggest any treatment, I should be glad to try it another year, for I dislike to be obliged to give up growing asters, but will have to unless some remedy can be found for the trouble.*

The disease is one that requires further investigation, especially in the field near greenhouses where the asters are grown, in order that the first stages can be more closely observed. The cause of the disease is not unlikely due to some improper method of cultivation; at all events, it is not desirable to recommend any method of treatment until more is known about it. In one instance, when the plants were badly affected in 1895, they were raised in a new field the following season, with the same disastrous results.

In this connection we wish to state that Professor Smith observed some aster plants in a small bed last summer quite similarly affected, but in this instance the death of the plants was undoubtedly caused by a small grub which devoured the roots.

"Leaf Spot" of Decorative Plants.

We use here the term "decorative" in a special and limited sense, as it is ordinarily used by florists, meaning to include such plants as palms, Dracænas, Ficuses, etc., which are used mostly or entirely for the ornamental effect of the plant as a whole, and this on account of the leaves. Specimens of such plants may be found in almost any florist's establishment, the leaves of which are more or less "spotted;" that is, certain portions of the leaf are dead and withered, and contrast prominently with the surrounding green tissues. Sometimes all the leaves on the plant are affected; again, only a few show any spotting. Sometimes almost the entire leaf is dead; in other cases, only a small spot. Such plants, if at all seriously affected, are of course almost valueless for decorative purposes, and even in less serious cases their beauty is greatly impaired; consequently it is well worth an effort to get rid of such disfigurations, and prevent their reappearance. In order to do this, we must first know the cause or causes of the difficulty. They are extremely various. Any injury, or weakening of the vitality of the plant in any way may produce the effect indicated by the well-known expression "leaf spot." It may be nothing more than a simple burn, produced by the sun's rays concentrated in passing through the glass roof and drops of water on the leaves, or, as frequently happens, by contact of the leaves with the heating pipes. The attacks of insects also sometimes have quite a similar effect. But the trouble is not always so obvious. Various other agencies conspire to produce the effect which we are considering.

---

* We attempted to obtain specimens of diseased plants from the Springfield growers, but unfortunately it was so late in the season when the disease was reported from this locality that we were unable to do so, as the affected plants had been destroyed.

It may be stated, as a general principle, that the healthy and rapidly growing plant is the least likely to fall a prey to disease. Exceptions to this may be found in the case of unusually vigorous outbreaks of the most destructive diseases, but in the long run the rule holds good. Let the plant become weak and sickly from improper and insufficient nourishment, too much or too little heat, light, water, etc., poor ventilation or drainage, or any other disturbance of its normal functions, and its liability to disease becomes largely increased. At such a time the weakening of the plant's vitality may proceed so far as to cause a gradual dying away of the leaves and thus produce spotting, or it may, and always does, favor the attacks of parasitic vegetable organisms, most of which belong to the class called the fungi. Such attacks, together with those of bacteria and other vegetable organisms of low rank, are alone properly considered as plant diseases. The fungi are true plants, but of low order and microscopic in size. Some of them are strictly parasites, *i.e.*, they can live only upon the tissues of other organisms. Others, like the toad-stools, are strictly saprophytes, *i.e.*, they live only upon dead and decaying organic matter. These are entirely harmless to plant life. Still others, while ordinarily saprophytes, have parasitic tendencies, and may attack plants in a weak and unhealthy condition. A sickly or injured plant may be attacked by a variety of such forms, together with true parasites, bacteria, insects and other organisms both of the animal and vegetable kingdoms, making it impossible to say which was the original cause of the trouble, if, indeed, any one of them could be strictly considered as such.

A leaf spot produced by fungi is a place on the leaf where a fungous plant has become established and consumed the vital substance. The spot becomes larger as the fungus grows out into new tissue. Fungi reproduce themselves by *spores*, corresponding to the seeds of higher plants. These spores are of course extremely minute, and are produced in infinite numbers. They are smaller than the finest dust, and float about in the air with the greatest readiness.

In the treatment of fungous diseases only one course of action can be successful. This is *prevention*. A leaf once infested with a fungus can never be restored to its normal condition, for not only is the fungus within its tissues and out of reach of any treatment, but, furthermore, certain parts of the leaf are already dead, and can never be restored. One method of preventing such diseases is by killing the spores before they can germinate. The now common operation of *spraying* consists in applying to plants affected or liable to be affected by disease certain substances diluted with water to a strength sufficient to destroy the fungous spores but not injure the leaves. This solution is applied in the form of a fine spray, by means of a pump and nozzle. The application of this method is now well established in the treatment of most of our destructive plant diseases, especially those affecting fruits and vegetables. The most effective substance thus far discovered for spraying purposes is the so-called Bordeaux mixture, — a sort of blue whitewash, made by combining lime with copper sulphate (blue stone, blue vitriol). Many other substances have been tried, some with great success; but the Bordeaux mixture is still the most satisfactory for general purposes, for it kills the spores, sticks to the leaves and does not injure the plant.

But in the case of decorative plants, even if the Bordeaux mixture effectually prevented disease, its use would involve a serious disadvantage. Imagine a fine palm or Ficus covered with blue whitewash! It would certainly be more disfigured than by any disease. We have, however, other fungicides which have given very satisfactory results in the treatment of plant diseases, and which, being clear solutions, leave no stain on the plant. Among these the so-called ammoniacal copper carbonate solution is one of the best. It is prepared by dissolving one ounce copper carbonate in strong ammonia (26°), of which about one pint will be required. The copper carbonate should be put into a wooden pail with sufficient water to make a thick paste, and the ammonia then added. The resulting solution is then diluted with about nine gallons of water.

But, aside from any method of spraying, much can be done for the eradication of spot diseases by removing and destroying all affected leaves, etc. This must be done promptly and thoroughly, in order to be effectual. As soon as a leaf is seen to be spotted, it should be removed and *burned.* This will certainly lessen the extent of the disease, and will in many cases entirely eradicate it, if the plant be kept in good growing condition. We would recommend, however, that all plants which have been or are liable to be attacked by such diseases should be sprayed with the above-described solution, the frequency of the operation varying with circumstances. A plant which has been diseased should be sprayed three or four times, at intervals of about two weeks. If then no further indications of the disease appear, spraying may be discontinued altogether, or the whole house may be thoroughly wet down with the solution every month or two, as a general precaution. (If the house contains any particularly delicate or valuable plants, it may be well to try the solution on a small scale on them before applying it generally. We have experimented with quite a variety of common greenhouse plants, and have experienced no harmful results. The solution should be diluted to the full extent recommended.) Spraying apparatus can be obtained of any dealer in agricultural implements.

But, after all, the perfection of spraying methods, however successful, is not the *ne plus ultra* of the science of growing plants. We would not in the least disparage the most exceedingly valuable results of the work done by experiment station workers and others in this direction. There can be not the slightest doubt that millions of dollars' worth of fruit and vegetables have been and will continue to be saved from destruction by this means. But the fact remains that success in growing plants, as in every other direction of human industry, comes not from the observance of any laid down rules and formulas, but rather is the reward of long experience, close application and intelligent skill. The triumph of the gardener's art is the plant brought to perfection in a natural, normal and healthy manner, and not that which owes its existence to skill in doctoring.

We will now briefly describe a few leaf-spot diseases which have come to our notice and which have received little or no public mention. The treatment which we have recommended will apply of course to these and any other similar diseases.

A Leaf Spot on Ficus elastica (India Rubber Plant).

(*Leptostromella elastica*, Ell. and Ev.).

The rubber plant, which is used quite extensively for ornamental purposes, on account of its large, dark-green leaves, is not often attacked by disease. In our own houses and also in other places in this State we have, however, recently found plants affected by a serious spotting of the leaves. The first indication of the disease is seen in the leaf's turning in small spots or streaks, which rapidly increase in extent, changing from yellow to a brownish color and finally to an ashy gray, when the affected portion is quite dead. At this stage the spots may include a large portion of the leaf or only a small part of it. There is often more than one on a leaf, but never a large number. The dead portion is sharply distinct from the living, and banded by a narrow black margin. Upon its surface little black dots appear, which are cavities containing the spores. The spots keep increasing in extent, until the leaf finally loses its vitality and falls from the plant. No plant more than ficus shows the effect of such a disease as this, since its handsome, dark-green leaves are its only ornamental feature.

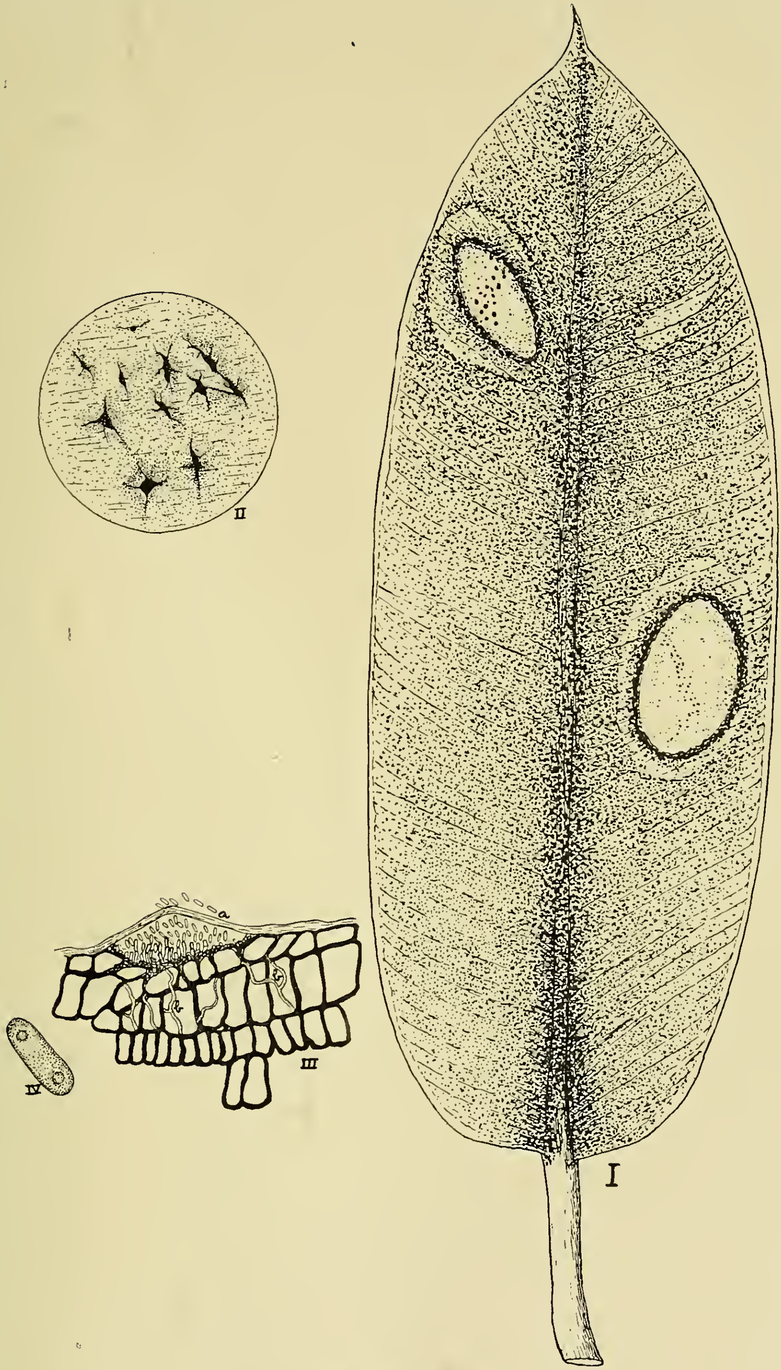


Figure 1.

I. Leaf of Ficus Elastica with spots caused by *Leptostromella Elastica.*

II. Surface of dead area enlarged, showing spore bearing cavities.

III. Cross section of dead area with spore cavity at *a* and filaments *b*, running among the cells of the leaf.

IV. A spore x 1300.

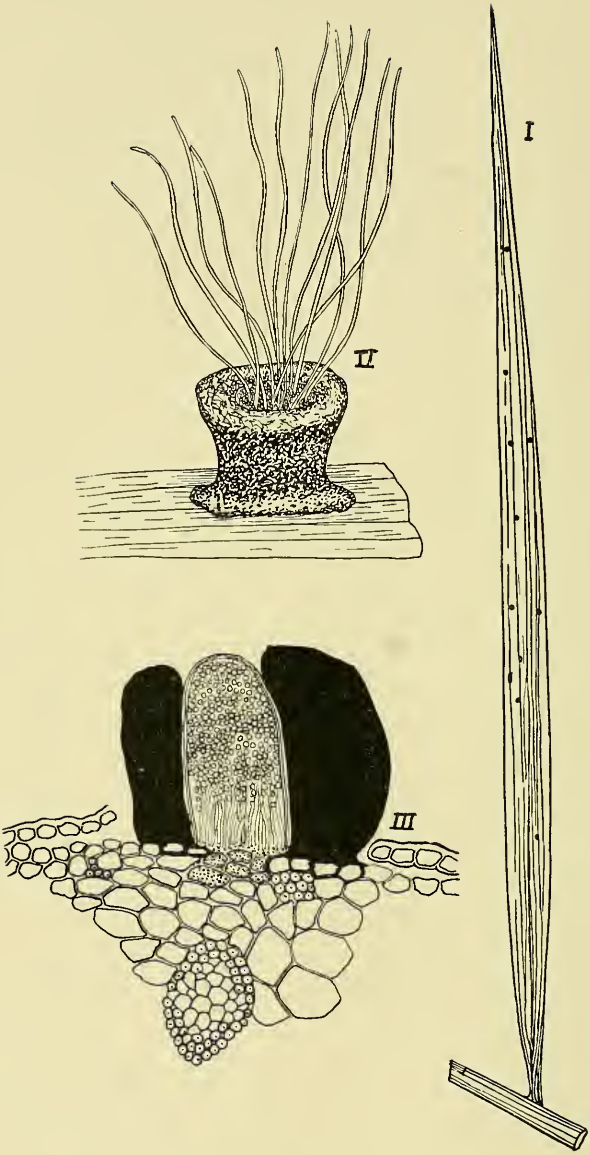


Figure 2.

I. Leaf of Phornix Canariensis attacked by *Graphiola Phornicis.*

II. Spore bearing conceptacle enlarged.

III. Section. of a conceptacle full of spore, and portion of the leaf.

This disease was first brought to notice by Prof. F. L. Scribner, in "Orchard and Garden," January, 1891, and scientifically described at about the same time by Mr. J. B. Ellis, from specimens sent by Professor Scribner. We find no mention of it since that time, which seems to indicate that it is not generally prevalent. Should it become so, it cannot fail to become very troublesome, for it spreads with considerable rapidity, and has a ruinous effect upon the decorative value of the plant. It was introduced into our houses, apparently, on a variegated-leaved Ficus elastica purchased from an outside florist. From this plant it spread to others of the ordinary green-leaved type, and has practically ruined several fine specimens. Great care should therefore be taken, in purchasing stock outside, that it be free from disease. (Not infrequently we hear of Ficus plants whose leaves turn yellow and drop off. This marks the normal end of the existence of the leaf, or, if it occurs extensively, an unhealthy condition of the plant, and is not to be confused with the fungous disease. An effect almost exactly similar, superficially, to that of the latter, is sometimes produced by sunburn.)

A Leaf-spot Disease of the Date and Similar Palms (*Phœnix* sp.).

(*Graphiola Phœnicis*, Poit.)

This disease is by no means a new or unknown one, but it has received little attention from an economic stand-point. It attacks various species of Phœnix in cultivation, and injures and disfigures them to a considerable extent. The affected parts of the leaf become mottled with yellow, and upon the surface little black eruptions appear, which are cup-shaped conceptacles produced by the filaments in the interior of the leaf, and in which the spores of the fungus are produced. These little eruptions are about one-fiftieth of an inch high and twice as wide, — plainly visible, therefore, to the eye. They consist of a firm, dark-colored exterior layer, enclosing a more delicate inner covering, which contains a mass of thread-like filaments on which the spores are produced. The leaf becomes thickly dotted over on both sides with the conceptacles and slowly shrivels away and dies, innumerable spores being produced meantime, which are ready to attack new leaves and plants. A fair-sized plant of Phœnix canariensis, sent in for examination and treatment, was found to be badly affected with this disease, and was treated as recommended above. All leaves which showed any sign of the disease (which included all the larger leaves of the plant) were cut off at the base. The plant was then sprayed, and has since developed new leaves which show no sign of the disease, though it is now nearly a year since the plant was received.

A Leaf-spot of the Begonia.

While it may be questioned whether the value of the begonia is strictly that of a decorative plant, in the sense in which we have been using this term, still, it cannot be denied that the plant is often used for this purpose, and on that ground we will consider in this category a spotting of its leaves which has come to our notice. Ordinarily the begonia is seldom affected by disease, insects or any other injurious agency. Still, it is not invulnerable, and we find occasional reports of diseased plants. In the English journals, "The Garden" and "The Gardener's Chronicle," a discussion runs along through several numbers in 1895, concerning a so-called "begonia rust," which seriously affected tuberous begonias. This, however, was finally settled on good authority to be insect work. "Damping off," a fungous disease of begonia and many other kinds of seedlings, is not uncommon. Professor Halsted of the New Jersey Agricultural Experiment Station mentions two leaf-spot diseases of begonia in the "American Florist," September, 1894, one caused by nematode worms, the other a fungous disease.

During the past year or two we have met with a definite spot disease on begonias, mostly of the tuberous variety, which is quite prevalent in our houses and those of a neighboring florist. We are not yet entirely certain as to the cause of the difficulty. The spot begins either on the margin or interior of the leaf, and slowly increases in size until the leaf dies and drops off. There are sometimes several spots on each leaf. As they increase in size their surface is

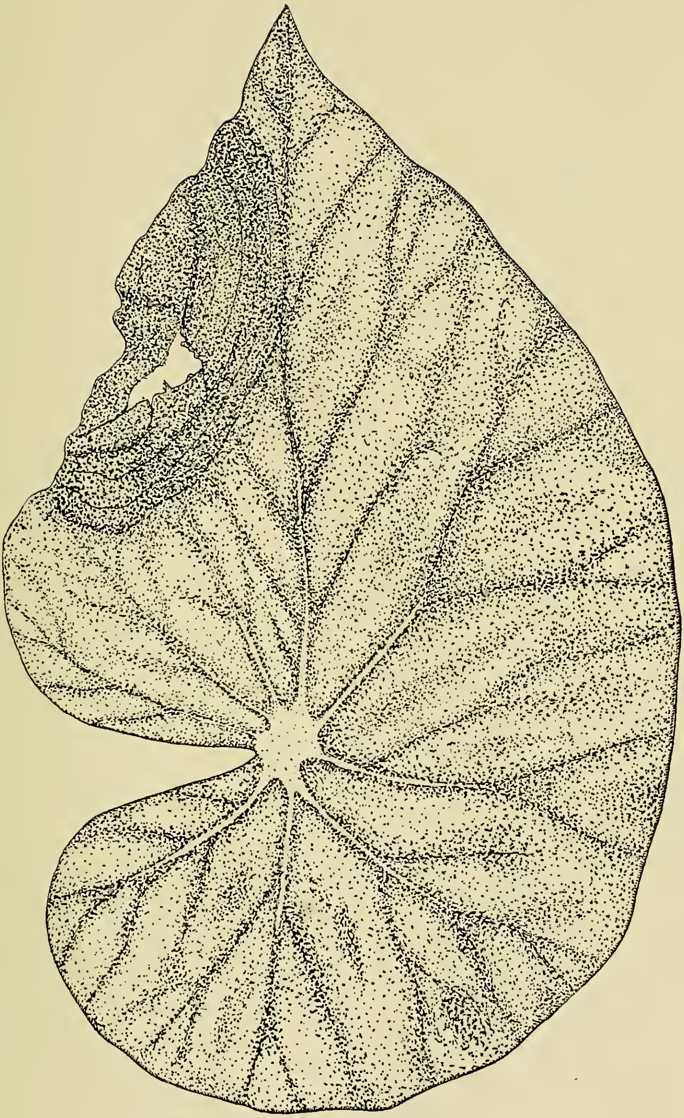


Figure 3.—Spotted Begonia leaf.

marked by concentric curved lines parallel to the edge of the dead portion, as in many spot diseases of fungous origin. Microscopic examination, however, shows nothing which may with certainty be decided upon as the cause of the trouble. We usually find fungous filaments and spores, but they are of many different species, and mostly moulds of a saprophytic or only partially parasitic nature, and cannot be regarded as the primary cause of the disease. In a few specimens we have found the spore-bearing conceptacles and spores of a fungus belonging to or near the extensive parasitic genus Glœosporium, which includes a great number of leaf spots. We consider this as the probable cause of the disease, but the spore-bearing material was very scanty, and we were unable to identify it with any described species. Possibly the trouble may be due to various causes, not all of a fungus nature, but appearances seem to indicate that there is a definite disease which causes most of the spotting. At all events, it will be a wise precaution, in this and all similar cases, to remove and burn all affected leaves.

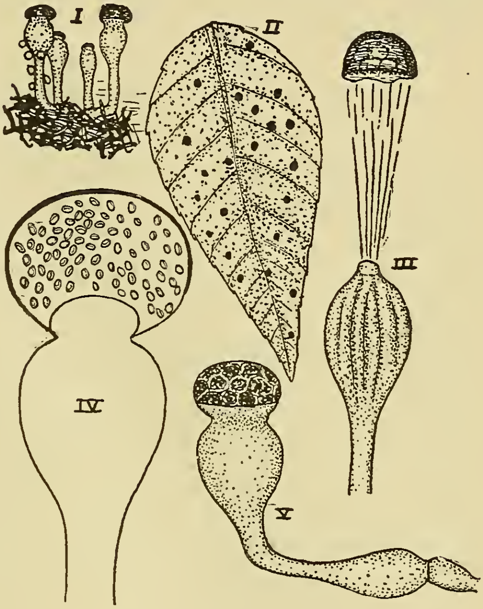


Fig. 4. — Pilobolus crystallinus, Tode.

I. Somewhat enlarged.
II. Sporangia on rose leaflet.
III. Discharge of sporangium.
IV. Section of sporangium and filament, showing spores.
V. Sporangium upon filament before being discharged.
III., IV. and V. are greatly enlarged.

Several other leaf spots of the palm, dracæna, ficus and other decorative plants have come to our notice. Some were only simple sun-burns, while others were real fungous diseases. What was at first thought to be Leptostromella elastica (the above-described leaf spot on Ficus elastica) upon Ficus religiosus, the banyan tree, proved to be simply a sun-burn, though its superficial resemblance to the fungous disease was most perfect. Quite a serious and apparently new spot disease of greenhouse orange trees has been met with, which is of true fungous origin. It is not necessary to describe all these forms in detail, as the treatment is practically the same in each case.

A So-called Black Spot of the Rose.

(*Plilobolus crystallinus*, Tode.)

It is not unusual to find rose bushes in the greenhouse thickly dotted over with little black specks, appearing not unlike "fly specks," which occur on all parts of the plants alike, and of course greatly disfigures the blossoms. Microscopic examination shows each speck to be a minute sac, filled with what are evidently fungous spores. It would thus appear that we had here a fungous disease, and as such it has been described under several different names. In fact, however, this is in no sense a disease, and the little sacs of spores have no real connection with the rose plant, being attached to it simply by cohesion. The sacs of spores or *sporangia* are produced by a fungus, Pilobolus crystallinus, which is strictly saprophytic, and grows on decaying manure. As such manure is usually placed upon the soil under roses, spores of the Pilobolus are introduced in it, and find a favorable place for development. They produce the thread-like filaments which make up a fungous plant, and on the ends of certain of them sporangia are developed. The filament behind each sporangium becomes filled with a watery fluid, which gradually increases in quantity, and exerts a pressure on the sporangium at the end. This pressure becomes so great that finally the sporangium, at about the time of its maturity, is forced from the end of the filament with sufficient power to send it a considerable distance. We have seen them on the roof of a rose house at least eight or ten feet from the soil where they were produced. Striking a plant, they adhere to it, and give the appearance of having developed there. We find them particularly on the rose, simply because the practice of covering the soil with manure is confined to the cultivation of that plant.

While this is not a disease in any sense of the word, still, the effect of the fungus on roses is of course disastrous to their beauty and salability. Knowing that the disfiguring sporangia come from the manure, where they can readily be seen in the morning in process of development, it would seem a comparatively simple matter to destroy them at that stage, either by mechanical means or by spraying with a fungicide.

A Leaf Blight or Anthracnose of the Cucumber.

(*Colletotrichum Lagenarium* (Pass.), E. and Hals.)

During the past summer we have received specimens of cucumber leaves from several different parts of the State, which were infested with a very destructive blight. In Arlington and Leominster, where the raising of hot-house cucumbers is carried on extensively, the disease was reported as doing great damage. The fungus which causes this trouble grows within the tissues of the leaf, and by sapping its vitality causes its death. Under favorable conditions it is very quick acting and extremely destructive. The infested leaf first shows yellowish spots upon its surface, which rapidly increase in size and become dry and dead. Various moulds often develop upon the dead areas, and, being more prominent than the fungus which really produces the disease, appear to be the cause of the trouble. A dark-brown, luxuriantly growing species of Macrosporium or Alternaria was particularly abundant upon the specimens received this summer, and had evidently been taken to be the cause of the disease, which was referred to as the "brown mildew," "brown leaf blight," etc. Such growths undoubtedly hasten the destruction of the leaf, but they are able to develop only upon leaf tissue which has been killed or greatly weakened by the other more strictly parasitic fungus which is invisible to the eye. The dead areas gradually fall away, leaving large irregular holes in the leaf, which in a short time becomes entirely dead. The same fungus often attacks the fruit, causing it to rot badly, and has been proven to be the cause of the well-known "rust," so called, of the pods and leaves of the bean. It also attacks the watermelon, musk-melon, citron, squash and pumpkin, affecting both leaves and fruit. We have recommended spraying every week or two with the

Bordeaux mixture for this and one or two other somewhat similar cucumber diseases, and have received reports from Arlington of favorable results from such treatment. While this is a most destructive disease if left unchecked, it ought nevertheless to be kept under control with comparative ease if judicious spraying with any good fungicide be combined with proper management of the crop.

An Unusual Outbreak of Two Rusts.

The Asparagus Rust (*Puccinia asparagi*, D. C.).

The rust of the asparagus has been known in Europe for more than half a century, and has caused more or less damage there. In this country it has been known for several years, but not at all extensively. During the present season, however, asparagus beds in various parts of this State, in New Jersey and doubtless in other States, have been seriously attacked by this rust, and are threatened with great injury should it continue to develop extensively from year to year. This fungus is one of the true rusts, and is quite similar to that attacking the wheat. Like it, there are three distinct stages of development, in each of which a different kind of spore is produced. According to European accounts, the rust first appears on the asparagus in the spring, at which time it produces the first kind of spores, the *æcidia*. These develop in turn during the summer, and produce the spores of the second or red-rust stage, the *uredo* spores. These again develop, and produce spores of the third or black-rust stage, the *teleuto* spores, which lie over winter and in the

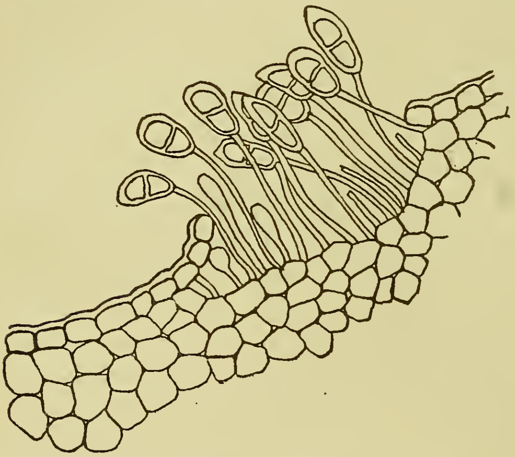


Fig. 5. — Section of a cluster of teleuto spores of *P.* asparagi, greatly enlarged.

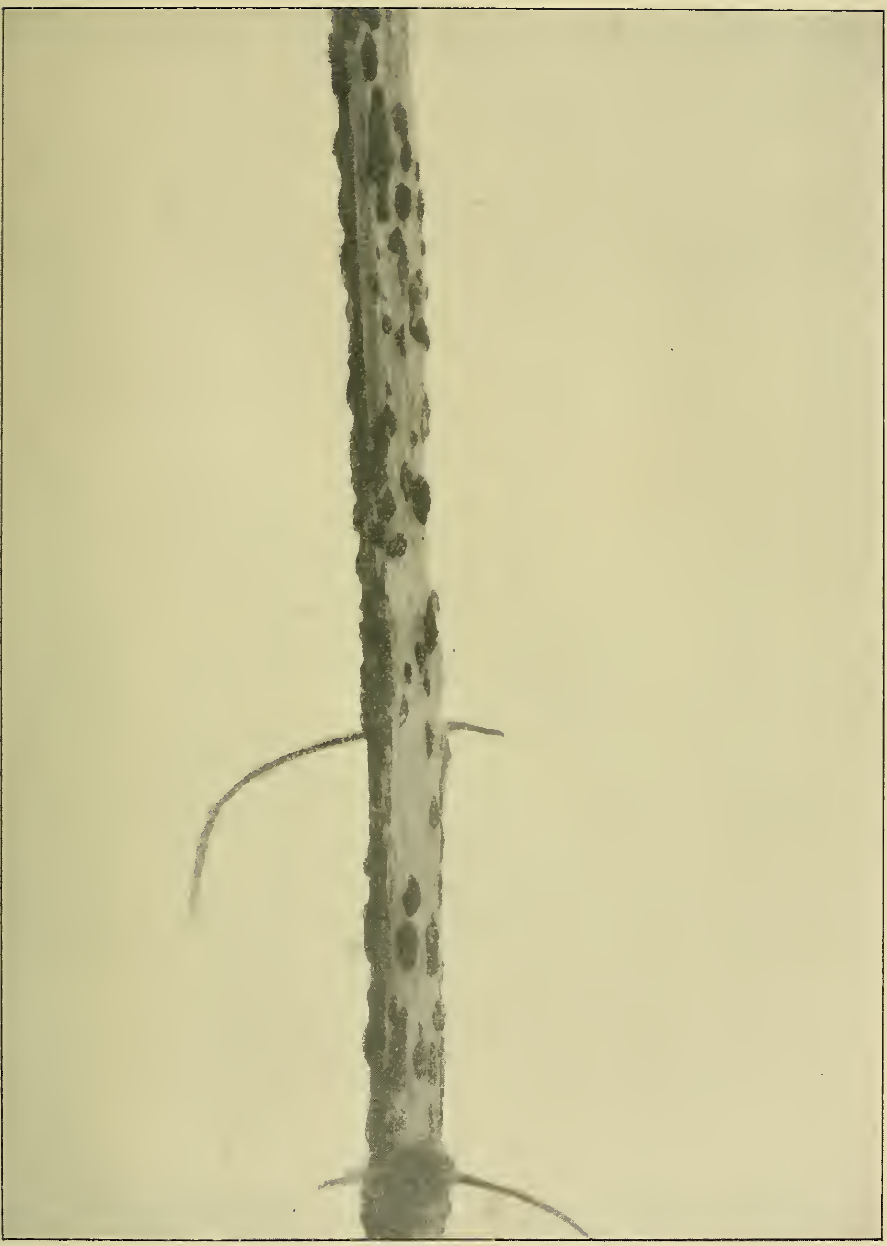


Figure 6. — Asparagus stem with rust.

spring attack the asparagus again, and produce æcidia. In each stage the fungus consists of minute filaments, which grow in the tissue of the plant and draw their nourishment therefrom. In some rusts one of the stages is most prominent, in others it is another. In the wheat rust the uredo or red-rust stage is perhaps the most conspicuous. In the present case the black or teleuto spores are most prominent. They appear in October and November, when the affected plant becomes thickly covered over with small, irregular black lines and blotches, which are the masses of spores pushing out through the surface. This is the stage which has been observed this fall in Massachusetts and New Jersey. Doubtless the other two stages were developed during the season, but did not become sufficiently prominent to attract attention.

Since this disease does not become prominent until late in the fall, and the asparagus crop is gathered in May and June, a question naturally arises as to how it can have any serious effect. There is indeed no great danger to be apprehended of its actually disfiguring the marketable product; but no plant can undergo a continuous and vigorous attack of a parasitic fungus without a serious loss of vitality, if it be not killed outright. If this rust appears only intermittently and not extensively, its ravages need not be seriously feared; but, should it continue to develop in the present abundance year after year for any considerable time, it cannot fail to become a most serious obstacle to the raising of asparagus. Moreover, we have examples in similar rusts, like that of the hollyhock upon its first appearance in Europe and later in this country, which have developed with unusual vigor and destructiveness immediately after their first outbreak in a new locality and climate. The raising of hollyhocks in Europe was well-nigh impossible for some time after the introduction of the rust. The progress of this asparagus rust is therefore worthy of close attention and some apprehension. Meantime, attempts should be made to check it as much as possible by cleaning up the bed in the fall and burning the infested tops, thus destroying countless numbers of spores. This should be done as early as possible, before the spores shall have become mature and scattered by the wind.

A Late Rust of the Blackberry (*Chrysomyxa albida, Kuhn*).

This rust, like that of the asparagus, has been long known in Europe, but only comparatively recently observed in this country. It was first brought to attention in America in 1886, but, while it has been not uncommon since then, it has never assumed any economic importance. Very likely it has been more or less confused with the spring orange rust (Cæoma luminatum, Lk.), which it slightly resembles, and on that account has escaped particular mention; still, it is hardly probable that it has been generally prevalent. In the season of 1894, however, it became decidedly abundant in our plantations, and caused considerable apprehension. It was also reported from other parts of the State, and threatened to become a serious matter. In 1895 it appeared again, but not so abundantly as in the previous season; and this year its attacks have been very slight, so that there seems to be no ground for fear of danger from this source at present.

Description. — This has been called the *fall* rust, to distinguish it from the *spring* rust, which appears much earlier in the season, and is entirely distinct. The latter is a well-known disease to fruit growers, as it causes much damage and has been the subject of many experiments and published articles. It attacks both blackberries and raspberries. Chrysomyxa albida comes on later, appearing in August and continuing through the fall. It does not attack the raspberry. It is one of the true rusts, having the three kinds of spores, as in the asparagus rust. In this case, however, it is the æcidia and uredo spores which are most prominent. These appear in small, powdery, scattered, bright orange-red spots on the under side of the leaf, and are consequently not as prominent as the indications of the asparagus rust.

While the same conclusions as to the future may be drawn in this case as in that of Puccinia asparagi, still, the results of three years' observation on the blackberry rust indicate that we have no great cause for alarm in that direction; while in the other case, having no such definite knowledge, we cannot but feel somewhat apprehensive until time shall show what is to be the result.

The Tomato Mildew (*Cladosporium fulvum*, Cke.).

The disease which is commonly called mildew is without doubt one of the greatest obstacles to success in growing tomatoes in the hot-house. While it does not always kill the vines outright, still, its effect in weakening their vitality and reducing their yield is a most serious one. We have received specimens of tomato leaves affected by this disease from several different localities, and have observed it in greater or less abundance in almost every house of tomatoes which we have examined. It also attacks tomatoes grown out of doors, but by no means so generally as in the hot-house.

When this disease comes on, there appear on the lower surface of the leaves brownish, felt-like spots of irregular shape and various sizes, which rapidly increase in extent, until the whole leaf finally turns black and withers away. It does not always spread so rapidly and kill the leaves at once, but is often found only on the lower leaves, or in spots which do not increase rapidly in size. Nevertheless, it is constantly weakening the plant, and, let a favorable opportunity come, as come it will sooner or later, and it spreads through the house with great rapidity and destructiveness.

The fungus consists of a dense mass of thread-like filaments, which ramify through the leaf in all directions and more or less upon its surface. The felt-like areas on the under surface of the leaves are composed of a mass of spores and the filaments which produce them. The spores germinate readily in water, developing filaments similar to those from which they were derived. This species belongs to a group of fungi which are mostly moulds and mould-like forms, growing upon dead vegetable matter or plants in a weak and unhealthy condition. This mildew is especially active in attacking such plants, upon which it produces the above-described disastrous effect. Its development is also greatly favored by excessive moisture in the air, *i. e.*, a "muggy" atmosphere, which indeed is favorable to the development of most plant diseases. The tomato requires a considerable heat for successful growth in the hot-house. If, while the plants are growing rapidly, the temperature suddenly falls from any cause and they consequently receive a check in their growth, it will be a most favorable time for an attack of the ever-ready enemy, the mildew. Poor ventilation and partial exclusion of sunlight by crowding the vines too close together will produce a muggy atmosphere, and have a similar result. To prevent crowding, it is advisable to trim up the vines somewhat and train them to trellises or single stakes. Uniform heat, good ventilation and free access of air and sunlight to all parts of the plant will prove the most effective preventive of mildew. In our climate, however, the first two conditions are liable to prove antagonistic to each other; for in cold, windy weather it is impossible to ventilate the house without greatly reducing the temperature.

Spraying with the ordinary fungicides has proved effectual in preventing this disease. The spraying should be done about once in two weeks, commencing when the plants are quite small. It is also a wise precaution in all hot-house work to thoroughly clean up and burn all dead leaves, vines and similar materials when a crop is removed, and, if possible, fumigate the house with sulphur. The latter of course cannot be done if there are any plants growing in the house.

Too often we find that such diseases as this are allowed to develope in the house, with no effort being made to check them. So long as the plants are not killed outright, many growers seem to think that no damage is done. This is certainly not the case, for the presence of the fungus is a constant drain upon the vitality of the plant, reducing its yield both in quantity and quality. The practice of spraying, which can be done at an insignificant cost per plant, will, if properly carried out, prove both effectual and profitable.

A Crysanthemum Rust.

Specimens of diseased chrysanthemum leaves which have been sent in to the station for examination prove to be affected with one of the true rusts, the first, so far as we know, to be reported upon this host. The specimens were sent by Mr. Geo. H. Hastings of Fitchburg, Mass., who writes as follows: —

The "rust" is quite common on the chrysanthemum leaves. In the advanced stages it completely kills the leaf. It seems to me that it is a very bad enemy to fight. I had plants enough to bring seventy-five or a hundred dollars worth of flowers, and I would not sell one flower, as I did not wish to have the name of selling such flowers. The plants were grown in the garden and "lifted" about the middle of September. The rust was on the leaves at that time, and some of them were dead.

The rust was in the uredo or red-rust stage, and proved to be a form closely resembling and probably identical with Puccinia Tanaceti, S. (P. Helianthi, D. C.), which occurs commonly upon Tanacetum vulgare (tansy), several species of Artemisia (ragweed) and Helianthus (sunflower), and several other related plants. Upon these plants it sometimes acts most destructively, as it has done in this instance upon the chrysanthemum. It bids fair to become a serious obstacle to the cultivation of this valuable flower.

Experience has shown that in the development by cultivation of any plant, as it becomes changed more and more from its natural form and forced into an abnormal development, its power to resist the attacks of disease becomes diminished. For this reason reports of new diseases upon our various cultivated plants are of frequent occurrence. All such diseases are certainly not new in the sense of being caused by a kind of organism which never existed before, but only new upon some particular kind of plant, which has, by reason of its forced and abnormal development, lost the power to resist the attacks of the parasite, which has existed all along upon some other kind of plant, and very likely in a milder form.

The chrysanthemum in its present form is a comparatively new plant in this country. Its great popularity has led growers to make extraordinary efforts to force its development along certain lines, notably in size of flowers. The production of flowers eight inches in diameter by a plant destined by nature to produce them less than quarter that size cannot be accomplished without bringing about serious changes in the vital functions of the plant, and making it more susceptible to disease. Therefore the list of chrysanthemum diseases may be expected to gradually increase, as it is now doing. At least two have been previously known. *The leaf spot* (Septoria sp. and Phyllostica sp.) was first described by Professor Halsted of the New Jersey Experiment Station several years ago, and occasions more or less damage. *The mildew* (Erysiphe Cichoracearum D. C.) has appeared more recently, and is rapidly increasing. This has a history very similar to that of the rust under consideration, being very common on Helianthus and Artemisia, as well as many other plants.

We can make no definite recommendations at present as to a treatment for this rust, it having been reported so late in the year. The true rusts are notoriously difficult to combat; the most so, perhaps, of any class of diseases. Many methods of treatment have been tried, but few with decisively profitable results. That panacea of plant diseases, the Bordeaux mixture, has been frequently recommended and tried for various rusts, with widely varying results. The same can be said of another common fungicide, the ammoniacal copper carbonate. Stewart, of the New York Experiment Station, reports, in the case of the carnation rust (Uromyces Caryophyllinus (Schrank) Schrt.), that a solution of potassium sulphide, one ounce to one gallon of water, was most effective. This strength might injure chrysanthemum leaves. One ounce to four or five gallons of water would be safer, but not, of course, as effective. With the hollyhock rust (Puccinia Malvacearum, Mont.), a very destructive disease, Mr. H. L. Frost of Arlington informs us that he has tried the Bordeaux mixture and also the commercial fungicide called "Fostite," with results in favor of the latter. It is possible, then, that some of these substances may be effective in preventing this chrysanthemum rust, but we cannot vouch for it. It would certainly be advisable to spray the plants occasionally with the Bordeaux mixture or with potassium sulphide, *commencing in the summer, when they are young and before any disease appears.* If the plants are healthy when put into the house, one or two sprayings thereafter should be sufficient to carry them through the season. All plants known to be diseased should be removed and burned.

We would urge any grower who has been troubled with any disease of his chrysanthemums to carry on a series of experiments with various fungicides, in order to get at some idea of the best method of treatment. Without such co-operation on the part of the grower we can do but little toward remedying such a disease as this, which does not occur everywhere, and consequently can only be experimented upon wherever it may happen to break out. The same is true with many other diseases, especially those affecting various hot-house plants. If we could plant chrysanthemums and be sure of getting rust, mildew and leaf spot, and similarly with other plants, if we could be sure of getting all their diseases, then our opportunities for experiment would be unlimited; but such, of course, is not the case. While some diseases are very general, many others appear only here and there, and the opportunities for experiment are limited to those places. We will gladly aid any one as much as possible in carrying on such experiments, and will give them our personal attention so far as we may be able.

"Drop" of Lettuce.

This disease has been for the last few years the most difficult one with which the lettuce growers about Boston have had to contend. Some growers always have a large number of plants attacked, while others have it so badly that they frequently lose half the crop. The annual loss to the lettuce growers about Boston from this disease alone amounts to several thousand dollars. The effect of the disease shows itself in a single night, and it is not very difficult to detect, inasmuch as the whole plant simply collapses. It not only makes its appearance on the young plant a few weeks old, but on the mature ones as well. Lifting the diseased plant out of the soil, it shows at once that the trouble is localized in the soft, rotten stem, which is not unusually covered with fungous growths sufficiently thick to be seen with the naked eye. Examination made with the microscope reveals the presence of numerous fungous filaments ramifying throughout the stem and root. The organism causing the disease is a species of damping fungus (Botrytis), which has previously been described in the ninth annual report of this station.

Practical lettuce growers resort to various methods in order to contend with this foe, but none of them have proved wholly effectual. Most of them recognize the fact that the source of contamination is largely in the soil, and that the disease is much more troublesome in old soil than in new. This is what might be expected, especially when the old decomposing roots are left in the soil, as they often are, thus offering the most favorable conditions for the spread of the disease. As a means of controlling it, some growers have resorted to changing the soil, with beneficial results; while others make a practice of covering the surface with a layer of pure sand or yellow subsoil, about one inch in depth. The burning of sulphur in the house before a new crop is set is also practised, and this might be expected to kill the spores with which it comes in contact; but it is very doubtful whether the sulphur affects the spores in the soil to any great extent. It appears, however, that sulphur penetrates the soil somewhat, and, on account of the injury which young plants are known to receive from sulphur, they should not be set for a few days after it is used.

The disease appears to be more common than formerly, and this is partially due to the practice of running high night temperatures. The collapse of the plant is most likely to occur during the night, and with a lower night temperature — for example, one not exceeding 38° to 40°F. — the trouble would no doubt occur less frequently. The opportunities for treating the soils with chemicals do not appear to us to be very promising, for the reason that solutions which would be likely to cause the death of the fungus would have to be used in very large quantities, as well as much stronger than in ordinary cases, and they would be likely to cause injury to the crop. My experiments in applying a great variety of chemicals to the soil have shown that, while a comparatively weak solution accomplishes all that can be desired in the laboratory, when applied to the soil the effect of even much stronger solutions more copiously applied is radically different. So long as the tendency is to force crops more and more, it must be expected that the gardener will have numerous abnormal conditions to contend with.

No doubt the most successful and I believe the cheapest method in the long run would be to apply heat as a remedy for fungus and other pests in the soil. I have used a great many pots of earth heated with steam up to 130° to 200°F., with the most beneficial results, not only in the subsequent growth of the plant, but also in destroying the troublesome pests which infest the soil. The soil under glass could be easily fitted up with a system of irrigating tile, which could be used not only for purposes of irrigation, but also for forcing steam through them and partially sterilizing the soil. I have not as yet had an opportunity of treating this fungus with heat, but I should suppose that, if the soil was heated to 200° F., it would result in its death.

PHYSIOLOGICAL DISORDERS.

Wilt of Maple Leaves.

Last May a number of maple leaves in a dry and crispy condition were sent to this department from various parts of the State, under the supposition that they were affected by some form of fungus or insect life. Examination of the leaves, however, by Mr. Robert A. Cooley of the insectary, showed that no form of either of these organisms could be found. All of the leaves that were sent in were those of the sugar maple (Acer saccharinum), although the same condition was observed in a large number of different varieties of Japanese maple growing on the college grounds. Moreover, they showed the wilt only on one side of the tree, namely, the west, that being the direction of the prevailing wind the day upon which they were affected; and this peculiarity — so far as could be learned — was the same all over the State. This phenomenon is especially interesting, as it occurs on apparently healthy trees under certain exceedingly unusual conditions, — conditions, too, which, lasting only a few hours, are yet capable of giving rise to abnormalties of function. We attribute the wilting of sugar-maple leaves, which occurred quite generally throughout Massachusetts on May 18, to an excessive transpiration or evaporation of water from the leaves, at a time when the water supply of the roots was extremely limited. This was brought about by a remarkable combination of meteorological conditions favorable to this result. It is well known to vegetable physiologists that agitation of the leaves of a plant greatly accelerates the process of transpiration, that is to say, the evaporation of water from the leaves. It is also well known that transpiration is accelerated by light, a low relative humidity and a high temperature. Such were just the conditions upon May 18.* During the months of April and May the rainfall was far below the normal, while the long-continued drouths of the two preceding years will be well remembered. Thus it is evident that the supply of water available to vegetation must have been much less than usual, and under the unusually strong, dry and warm wind of May 18, the leaves of a tree like the maple, with its large leaf surface, might be expected to become greatly exhausted and wilt badly. When this wilting was not carried to excess the leaves recovered; when, however, it went too far, it resulted in a dying and subsequent shrivelling of the foliage.

Another factor which must not be overlooked in accounting for this disorder is the maturity of the foliage. Young leaves always give off the greatest amount of water, and the maple leaves in May are giving off their maximum quantity.

With plenty of water in the soil these high winds would not have caused any wilting; or, if the same conditions had ensued during August or September, when the foliage was more mature, less wilting would have resulted. The west side of the trees, being the side exposed to the prevailing winds, was the most severely affected.

Top-burn of Lettuce.

A disease occurring on greenhouse lettuce, and characterized as "top-burn" came under our observation the past winter. The disease can readily be distinguished by the withering and subsequent turning back of the tip and margin of the outer leaves, the blackened area sometimes extending inwards an inch or more from the margin. This feature greatly disfigures the plant and consequently affects its market value, but the real damage to the lettuce plant is never sufficient to destroy it. Microscopic examination of the blackened areas frequently shows bacteria in the cells, but more often the "damping fungus" (Botrytis) is present, and can be readily observed with the naked eye. In this instance, however, neither of these forms of organisms has anything to do with the cause of the disease. They are simply accompanying factors, which are always ready to seize upon any abnormal condition in the plant which is especially favorable to them. The disease is a physiological one, and has its origin in the unfavorable surroundings of the plant, especially those connected with transpiration and sunlight. Mr. B. T. Galloway of the United States Department of Vegetable Physiology and Pathology has made this disease a study, and I can do no better than to quote his views: —

---

* Meteorological conditions were as follows: total precipitation, April, 1896, 1 32 inches; April, 1895, 5.60 inches; May 1–18, 1896, .16 inch. May 18, maximum velocity of wind 71 miles per hour; relative humidity, 47.31 (average for May, 62 5); number hours sunshine, 13 (in possible 14½); maximum temperature, 84°.

> Top-burn, one of the worst troubles of the lettuce grower, does comparatively little injury on this soil [Boston soil], providing the proper attention is given to ventilation and the management of the water and heat. Burn is the direct result of the collapse and death of the cells composing the edges of the leaves. It is most likely to occur just as the plant begins to head, and may be induced by a number of causes. The trouble is most likely to result on a bright day following several days of cloudy, wet weather. During cloudy weather in winter the air in a greenhouse is practically saturated, and in consequence there is a comparatively little transpiration on the part of the leaves. The cells, therefore, become excessively turgid, and are probably weakened by the presence of organic acids. When the sun suddenly appears, as it often does after a cloudy spell in winter, there is an immediate rapid rise in temperature, and a diminution of the amount of moisture in the air in the greenhouse. Under these conditions the plant rapidly gives off water, and, if the loss is greater than the roots can supply, the tissues first wilt, then collapse and die. The ability of the roots to supply the moisture is affected by the temperature of the soil, the movement of water in the latter and the presence or absence of salts in solution. In this soil the temperature rises rapidly as soon as the air in the greenhouse becomes warm, and the roots in consequence immediately begin the work of supplying the leaves with water. The movement of the water in the soil is also rapid, so that the plant is able to utilize it rapidly.

While I have never seen the disease in the lettuce houses about Boston, the growers seem to be acquainted with it; and it is no doubt the superior skill which they possess that enables them to be free from it. One grower informed me that he always saturated his house with moisture in bright, sunshiny days which were preceded by cloudy weather, and by this means was able to prevent it.

REPORT OF THE ENTOMOLOGIST.

CHARLES H. FERNALD.

In the early part of 1896 the gypsy moth report mentioned last year was published by the State. This work consists of a bound volume of 608 pages, with 3 colored and 63 uncolored plates, and with 5 maps and 37 cuts in the text. The first part, comprising 263 pages, was prepared by the field director, and the second part, 244 pages, by myself, while the Appendix of 100 pages contains the reports of visiting entomologists and other papers. This work represents all that we were able to learn, up to the time of publication, of the history and habits of the notorious gypsy moth, its ravages in foreign countries as well as in our own, the means used for fighting it in other lands and also its natural enemies. Our experiments with methods for the destruction of this insect are still in progress, and occupy a large amount of time in study and work.

Quite extended studies have been carried on during the year on the spruce gall-louse (*Chermes abietis* Linn.), mainly by my assistant, Mr. R. A. Cooley, who with great care and perseverance has worked out the life history of this insect, which causes peculiar cone-like galls to form on the twigs of different varieties of spruce, rendering them unsightly and often nearly destroying them. The results of these studies are published in the thirty-fourth annual report of the college, with two plates showing the work and different stages in the life of this insect. Mr. Cooley was fortunate enough in his experiments to discover a good practical remedy for this insect, which consists in spraying the trees with a strong solution of whale-oil soap at the time these insects are in the most exposed state, which occurs during the winter or in the early spring, and also to cut off and burn the new galls in June before the insects leave them. About five hundred circular letters were sent to all parts of the country last spring, and from the replies to these it appears that this insect already has a wide distribution in this country, and it is quite probable that in time it may become distributed wherever spruces grow.

Considerable time has been devoted to the study of cranberry insects during the summer, three trips having been made to the bogs on Cape Cod at the most favorable time for the study of these insects. There are, however, so many different species attacking the vines, and their mode of attack is so different one from another, that to learn their habits and the most effectual and economical method of destroying them forms a problem of no easy solution. We are therefore not yet ready to publish a final bulletin on these insects.

The army-worm has been unusually abundant the past year in many parts of the State, and numberless calls have been made on this department for information concerning the insect; in fact, the correspondence about the army worm during the summer was far greater than that of all other insects combined. Fortunately, we had already published a bulletin on this insect, and Mr. Kirkland, my assistant on the gypsy moth work in Malden, published an article on the army-worm in the "Crop Report" for September, 1896. It is not possible to foretell whether this insect will occur in injurious numbers next summer; but such a case would be quite unusual, as it has very rarely if ever in the past been abundant in the same locality two years or more in succession.

The elm-leaf beetle has not been so abundant in this State during the past summer as it was the year before, and this is true, as I learn, in other States. What the real cause of this decrease in numbers may be, I do not know. It may be due to a rapid increase of its vegetable parasites favored by a wet season. This, however, is all conjecture, as I have no positive evidence in the case.

The San José scale has occupied much attention; and, at the request of the president of the Shady Hill nurseries, I sent an assistant to make a critical examination of their stock at Bedford, Mass., and he reported to me that he discovered a large amount of infested stock in that nursery, which the president promised to have burned. An examination made late this fall reveals the fact that the scale has not been entirely cleared from it. How widely this scale may be distributed in this State I am not able to say.

On the 12th of May I received a letter from L. C. Holt, Esq., of Ashby, Mass., and also a box of caterpillars which he stated were in immense quantities on the blueberry bushes, entirely stripping them of their leaves, and that unless something were done at once there would be no blueberry crop, and this would be a great misfortune, as many poor people derived quite a revenue from the berries picked from these bushes. The caterpillars proved to be the currant span worm (*Diastictis ribearia* Fitch); but the great difficulty which now presented itself was to offer some remedy which would not be as expensive as the value of the crop. I could think of no better or cheaper mode of destroying these span worms than to spray the bushes with Paris green in water, in the proportion of one pound of the former to one hundred and fifty gallons of the latter, and advised this course, if the crop was of sufficient importance to warrant the expense. This is the first time I have ever heard of this insect attacking the blueberry.

On the 17th of November I received a letter enclosing some twigs with scale insects on them from Mr. James Draper, who wrote me that they were taken from a golden-oak tree in one of the gardens of the city of Worcester, Mass. The scales proved to be what is known by the name of *Planchonia quercicola*, a European scale insect which has been in this country for some time. The first account of it here, so far as I know, was given in the report of the Department of Agriculture for 1880, page 330, where it is stated that it was found upon the imported oaks in the Department of Agriculture grounds at Washington. The insect has been found in New Jersey and also in New York, as I am informed by Professor Howard. It is regarded as a very injurious scale, and every effort should be made to destroy it by cutting off and burning the infested twigs, and thoroughly spraying the trees with whale-oil soap dissolved in water.

REPORT OF THE CHEMIST.

DEPARTMENT OF FOODS AND FEEDING.

J. B. Lindsey.
Assistants, E. B. Holland, G. A. Billings,* B. K. Jones.

Part I.

Laboratory Work.

Outline of year's work, together with chemical investigations of a technical character.

Part II.

Feeding Experiments and Dairy Studies.

(*a*) Effect of narrow and wide rations upon the quantity and cost of milk and butter, and upon the composition of milk.
(*b*) Rice meal *v.* corn meal for pigs.
(*c*) Oat feed *v.* corn meal for pigs.
(*d*) Digestion experiments with sheep.

Part III.

Compilation of fodder analyses.
Compilation of fertilizer constituents of fodders.
Compilation of analyses of dairy products.
Compilation of digestion coefficients.

---

* Left Sept. 1, 1896.

PART I.

We have continued to analyze, free of cost, all feed stuffs, dairy products and waters sent to the station during the year. Results have been reported as promptly as possible, together with such comments as were considered necessary. There have been tested 63 samples of feed stuffs, 89 samples of whole milk, 11 samples of skim-milk, 9 samples of cream and 6 samples of butter; also 31 samples of milk and 20 samples of butter for the Dairy Bureau. These results are tabulated at the end of this report.

There have also been examined 134 samples of water, of which 10, or 7.5 per cent., were pronounced excellent; 50, or 37.5 per cent., fair; 39, or 29.1 per cent., suspicious; and 35, or 26.1 per cent., dangerous for drinking purposes.

In addition to the analyses above mentioned, which may be regarded as control work, we have made a very large number of analyses of feed stuffs, manures and milks, in connection with various animal experiments.

We have also spent considerable time in attempting to estimate some of the various substances composing the non-nitrogenous extract matter, and have compared different methods for the determination of starch in different feed stuffs, with a view of selecting one that will most correctly ascertain the true starch, when in combination with other substances of a similar nature. The results of some of the work are very briefly presented under the following heads: * —

1. *Remarks relative to the carbohydrates of agricultural plants and seeds.*
2. *Distribution of galactan.*
3. *The phloroglucin method for the estimation of pentosans.*

---

* The work reported under these headings is of a technical character.

SOME REMARKS RELATIVE TO THE CARBOHYDRATES OF AGRICULTURAL PLANTS AND SEEDS.

J. B. LINDSEY.

Agricultural chemists have divided the dry matter of plants into five groups of substances, namely, crude ash, crude fibre, crude fat or ether extract, and non-nitrogenous extract matter. These terms, as is well known, do not stand for single ingredients, but rather for groups of substances having similar characteristics. The terms crude fibre and extract matter are spoken of collectively as carbohydrates. Our knowledge of the individual substances composing the fibre and extract matter has until recently been rather vague. The investigations of Tollens, Schulze and their pupils have, however, thrown considerable light, and revealed the presence and characteristics of many of the substances entering into their composition. The crude fibre of agricultural plants, as prepared by the method employed by Henneberg and Stohmann, is now known to consist principally of dextroso-cellulose (a hexa-cellulose), combined with more or less lignin or lignin acids. The fibre has also been found to contain considerable pentosan, so intimately associated with the hexa-cellulose as to be considered a penta-cellulose. Whether the penta-cellulose is actually united with the lignin as a ligno-cellulose is uncertain. The true celluloses are characterized principally by their nearly complete insolubility in dilute mineral acids and in F. Schulzes' reagent, and by their solubility in copper ammonium oxide. When cellulose is dissolved in quite concentrated sulphuric acid, and the resulting product hydrolized with dilute acid, Schulze has as a rule obtained dextrose; hence the name dextroso-cellulose. Schulze found that the cellulose obtained from wheat bran, peas and lupine seeds yielded only dextrose; that obtained from rye straw, lupine pods, spruce wood and red clover, gave dextrose and xylose; while that prepared from the coffee bean, cocoanut and sesame cake, yielded dextrose and mannose. There exist, therefore, dextroso-, mannoso- and pentoso- celluloses. That the so-called crude fibre is not pure cellulose, but in addition to both hexa- and penta- cellulose contains more or less lignin, is probable from the fact that it is colored a bright red by phloroglucin and hydrochloric acid, and because it contains a higher percentage of carbon than pure cellulose. When the dried and finely ground plant or seed is treated according to the Weender method, a considerable portion of the lignin is split off, and reckoned as extract matter.

The term non-nitrogenous extract matter is meant to include all substances, not included within the other four groups, that are removed by means of dilute acid and alkali. In case of the grains, the extract matter is known to consist largely of starch; but when derived from coarse fodders, leguminous seeds and many by-products, its composition has been, until the investigations of Tollens and Schulze, but little understood.

To these carbohydrates that can be removed from the plant by the action of dilute mineral acid and alkali, and that are as a rule soluble in F. Schulze's reagent, E. Schulze has applied the name *hemi-cellulose*. Under this head he would bring the mother substances, dextran, levulan, mannan, galactan, araban and xylan, which yield, on inversion, the sugars dextrose, levulose, mannose, galactose, arabinose and xylose. It is the mother substances of these sugars and probably others of a similar nature not yet identified, together with ready-formed sugars, starch, and a portion of the lignin, as above alluded to, which constitute the extract matter. These hemi-celluloses are intermixed with the true celluloses and ligno-celluloses in the cell walls of plants and seeds. In some cases they have been recognized as reserve material, and are used as food in the sprouting of the seed. The levulan and mannan do not appear to be generally distributed. The araban and xylan (pentosans), on the other hand, constitute fully one-third of the extract matter of all hays and straws; they are quite prominent in the hull and bran of different grains and seeds, and are even found in the endosperm and cotyledons of many seeds.

THE DISTRIBUTION OF GALACTAN.

J. B. LINDSEY and E. B. HOLLAND.

Galactan, one of the hemi-celluloses, was first extracted from lucerne seeds by Müntz,* and was converted into galactose by boiling with dilute acid. E. Schulze † and his co-workers found galactan quite prominent in the seeds of the blue lupine. The finely ground seeds were extracted with ether, alcohol, one per cent. soda solution at a low temperature to remove albuminoids, washed with water, and the residue boiled with dilute sulphuric acid. The solution was afterwards neutralized with barium carbonate, filtered, and evaporated to a syrup. This syrup was extracted with hot alcohol, and the alcoholic solution on slow evaporation yielded sugar crystals which proved to be galactose. The mother substance, yielding galactose, was also found to contain a pentose (probably arabinose). Schulze, therefore, called the substance para-galactoaraban. An examination of the pea, soy and field bean, showed the presence of the same substance. The coffee bean, date seed, palm and cocoanut cake proved the presence of galactan and mannan in liberal quantities, indicating the presence of a substance which might be termed galactomannan. Whether these substances are chemically united into complex molecules, or whether they are simple mixtures, it is hardly possible to state.

As a result of this work, Schulze assumed that the hemicellulose galactan might be very generally distributed in agricultural plants; and, if such should be the case, it must be of importance as a source of nutrition.

---

* Bull. Soc. Chim. (2) 37, p. 409.

† Zeitsch für physiol. chem. Bd 14. Heft 3; Zeitsch für physiol. chem. Bd 16, Hefts 4 and 5.

Recognizing the comparatively few fodder plants and seeds that had been tested for galactan, we thought it would prove interesting to make a quantitative estimation of the amount of the substance present in all the more important feed stuffs. While the method employed by Schulze, namely, the inverting of the galactan with dilute mineral acid and allowing the resulting sugar to crystallize out, is of course a sure proof of the presence of galactose, if properly identified, it does not admit of a *quantitative estimation* of the sugar. We therefore had recourse to the indirect method of estimating the mucic acid, as a measure of the quantity of galactose present. Scheele * was the first to recognize that by the oxidation of milk sugar, mucic acid resulted. Pasteur † found that it was the galactose of the milk sugar that yielded mucic acid. Tollens and Kent, ‡ after numerous experiments, proposed the following method for obtaining the largest amount of mucic acid both from milk sugar and from galactose. They evaporated 100 grammes of milk sugar with 1,200 c.c. of nitric acid of 1.15 specific gravity in a water bath to one-third of its volume, allowed the solution to stand twenty-four hours for the mucic acid to crystallize out, then filtered onto a tared filter and dried and weighed it. This method yielded 37 to 40 per cent. of mucic acid. When pure galactose was used, a double quantity — 74–77 per cent. — was obtained.§ Rischbieth, Creydt, Hadecke and Tollens still further perfected the method, and used it in ascertaining the galactan in a variety of substances. This perfected method we have used with but slight modifications in the estimation of galactan in the substances which follow.

Method. — Three grammes of the substance were brought into a beaker about 5.5 c.m. in diameter and 7 c.m. deep, together with 60 c.c. of nitric acid of 1.15 specific gravity, and the solution evaporated to exactly one-third of its volume in a water bath at a temperature of 94 to 96 degrees C. After standing twenty-four hours, 10 c.c. of water are added to the precipitate, and it is allowed to stand another twenty-four hours. The mucic acid has in the mean time crystallized out, but is mixed with considerable material only partially oxidized by the nitric acid. The solution is therefore filtered through filter paper, washed with 30 c.c. of water, to remove as much of the nitric acid as possible, and the filter and contents brought back into the beaker. Thirty c.c. of ammonium carbonate solution* are now added, and the beaker brought into a water bath and heated gently for fifteen minutes. The ammonium carbonate takes up the mucic acid, forming the soluble muciate of ammonia. The solution is now filtered into a platinum or porcelain dish, and the residue thoroughly washed with water to remove all of the muciate of ammonia. The filtrate is then evaporated to dryness over a water bath, and 5 c.c. of nitric acid of 1.15 specific gravity are added, thoroughly stirred and allowed to stand for thirty minutes. The nitric acid decomposes the ammonium muciate, precipitating the mucic acid, which is now filtered onto a tared filter, or into a Gooch crucible, washed with 10 to 15 c.c. of water, with 60 c.c. of alcohol and quite a number of times with ether, dried at 100° C. for a short time, and weighed. The mucic acid multiplied by 1.33 gives galactose, and this multiplied by .9 gives galactan.

---

* Opuscula chemica et physica, Leipsig, 1789, p. 111.

† Comp. rend. 42, p. 347.

‡ Ann. Chem. 227, p. 221.

§ Landw. Versuchs-Stationen 39, p. 401.

The method gives fairly good results, but, like other methods that are employed in estimating substances formed by physiological processes, absolute accuracy is hardly to be expected. For example, when extracting the mucic acid from the impurities with ammonium carbonate, more or less of the partially decomposed organic matter is dissolved out, which is again precipitated by the addition of the nitric acid. After the mucic acid is filtered and washed with alcohol and ether, a considerable portion of this material is dissolved out; some, however, still remains, and gives the otherwise white mucic acid a grayish color. It is possible that such a condition might be obviated by previously treating the *substance to be examined* with alcohol, ether and one per cent. soda solution in the cold, in order to remove fat, coloring matter and protein substances. Whether this could be done without loss of any of the substance is a question for further study.

---

* One part ammonium carbonate, 19 parts water and 1 part strong ammonia.

Results.

Coarse Fodder.

	Galactose.	Galactan.
	Per Cent.	Per Cent.
English hay,	1.01	.91
High-grown salt hay,	.93	.84
Black grass,	.71	.64
Corn stover,	.76	.68
Oat straw,	.81	.73
Rye straw,	.63	.57
Fodder millet,	.95	.86
Canada beauty pea fodder,	3.09	2.78
Medium red clover fodder,	3.73	3.36
Alsike clover fodder,	4.25	3.83
Mammoth clover fodder,	3.77	3.39

Concentrated Feeds.

	Galactose.	Galactan.
Corn meal,	.05	.05
Wheat meal,	.23	.21
Oat meal,	.81	.73
Barley meal,	.55	.50
Wheat bran,	.43	.39
Millet meal,	.67	.60
Linseed meal,	1.31	1.15
Cotton-seed meal,	.63	.57
Rice meal,	1.04	.96
Rape seed,	1.07	.96
Brewers' grain,	.56	.50
Malt sprouts,	.43	.39
Dwarf horticultural bean,	.68	.61
Green soy bean,	.67	.60
Black soy bean,	.92	.83
Bush lima bean,	.79	.71
Pole lima bean,	.66	.59
Black wax bean (dwarf),	.52	.47
White pot bean,	.53	.48
Horse bean,	1.83	1.65
Canada beauty pea,	.63	.57
Prussian blue pea,	.75	.68
English gray pea,	.84	.76
Little gem pea,	1.16	1.04
Wonder pea,	1.62	1.46
Pea meal,	2.69	2.42
Vetch seed,	1.17	1.05
Serradella seed,	.66	.59
Medium red clover seed,	2.77	2.49
Mammoth clover seed,	3.63	3.27
Crimson clover seed,	3.49	3.14
Alsike clover seed,	8.96	8.06
Sweet clover seed,	6.00	5.40
White clover seed,	10.08	9.07
Alfalfa seed,	5.23	4.71
White lupine seed,	13.84	12.46
Blue lupine seed,	16.29	14.66

Many of the substances tested show less than one per cent. of galactan, and we are not certain in many cases, because of the small amount of precipitate obtained, whether the material weighed really was mucic acid or partially decomposed organic matter. All substances, therefore, containing less than one per cent. of galactan, may be for the present characterized as doubtful. To settle the presence or absence of very small amounts of galactan, we shall either be obliged to still further perfect the method, or work with larger quantities. Tollens states that mucic acid melts at 213 degrees C. We have tested the melting point of the precipitate in cases when there was sufficient present, and found a melting point of about 215 degrees C.

The results as given above show the presence of very small amounts of galactan in the non-leguminous coarse fodders and seeds. In the leguminous plants from three to four per cent. are present, while in case of the leguminous seeds, several varieties of beans and peas appear to contain very limited quantities, but the larger number of such seeds tested show from 1½ to as high as 14 per cent. With the exception of the lupines, the clover seeds contain the largest amounts, the seeds of white variety containing 9 per cent.

The above results are merely a report of progress. They show, however, that the galactans are not as widely distributed nor present in such large quantities as are the pentosans, and therefore do not play such an important part as do the latter in the process of nutrition. We propose to continue the investigation of the distribution of these substances, and also to determine their digestibility.

THE PHLOROGLUCIN METHOD FOR THE ESTIMATION OF PENTOSANS.

J. B. LINDSEY and E. B. HOLLAND.

Councler * has suggested that, instead of phenylhydrazin, phloroglucin be employed for the precipitation and estimation of furfurol obtained by the distillation of various substances, with dilute hydrochloric acid. Kruger and Tollens † have further studied and perfected the method, and recommended it as reliable for the estimation of pentosans in various coarse fodders, grains and vegetables.

The phloroglucin, like the phenylhydrazin method, is based on the fact that the pentosans (araban, xylan, etc.) differ from other carbohydrates in that they yield furfurol instead of levulinic acid upon digestion with moderately dilute hydrochloric or sulphuric acids. The first step necessary in both processes for a quantitative estimation is the conversion of the pentosans into furfurol and its separation from the resulting by-products.

Phloroglucin Method described.

Three grammes of the material are brought into a ten-ounce flask, together with 100 c.c. of 12 per cent. hydrochloric acid (specific gravity, 1.06), and several pieces of recently heated pumice stone. The flask, placed upon wire gauze, is connected with a Liebig condenser, and heat applied, rather gently at first, and so regulated as to distil over 30 c.c. in ten to fifteen minutes from the time that boiling begins. The 30 c.c. driven over are replaced by a like quantity of the dilute acid, by means of a separatory funnel; and the process so continued as long as the distillate gives a pronounced reaction with aniline acetate on filter paper (a

---

* Chemikerztg, 1894, No. 51. † Zeitsch. für Ang. Chem., 1896, Heft II.

few drops of aniline in a little 50 per cent. acetic acid). To the completed distillate is gradually added a quantity of phloroglucin * dissolved in 12 per cent. hydrochloric acid, and the resulting mixture thoroughly stirred. The solution first turns yellow, then green; and very soon an amorphous greenish precipitate appears, which grows rapidly darker, till it finally becomes almost black. The solution is made up to 500 c.c. with 12 per cent. hydrochloric acid, and allowed to stand over night. In case there is very little furfurol in the substance tested, and the resulting distillate consequently small, it is best to add sufficient 12 per cent. hydrochloric acid to the distillate before adding the phloroglucin solution, so that, upon the addition of the latter solution, the resulting mixture will contain approximately 500 c.c.

The amorphous black precipitate is filtered into a tared Gooch crucible through an asbestos felt, washed with 100 c.c. of water, dried to constant weight by heating three to four hours at 100 degrees C., cooled and weighed, the increase in weight being reckoned as phloroglucid. To calculate the furfurol from the phloroglucid,† use the following table: —

TOTAL WEIGHT OF PHLOROGLUCID OBTAINED.	Divided by, equals Furfurol.	TOTAL WEIGHT OF PHLOROGLUCID OBTAINED.	Divided by, equals Furfurol.
.20 gramme, . .	1.820	.34 gramme, . .	1.911
.22 " . .	1.839	.36 " . .	1.916
.24 " . .	1.856	.38 " . .	1.919
.26 " . .	1.871	.40 " . .	1.920
.28 " . .	1.884	.45 " . .	1.927
.30 " . .	1.895	.50+ " . .	1.930
.32 " . .	1.904		

Furfurol ÷ by grammes substance taken × 1.84 = pentosans.
Furfurol ÷ by grammes substance taken × 1.65 = xylan.
Furfurol ÷ by grammes substance taken × 2.03 = araban.

---

* Dissolve twice as much dry phloroglucin as furfurol expected in about 50 c.c. of 12 per cent. hydrochloric acid. Bring the hydrochloric acid into a water bath, and stir thoroughly till the phloroglucin goes into solution.

† The phloroglucid is a complex substance, of uncertain formula. It contains 63 to 64 per cent. of carbon and from 3.6 to 4.2 per cent. of hydrogen. The factors for calculating the amount of furfurol from the phloroglucid were obtained after experimenting with known amounts of pure furfurol and phloroglucin.

The amount of pentosans was estimated by both the phenylhydrazin and the phloroglucin methods in the following substances: —

	Phenylhydrazin Method (Per Cent.).	Phloroglucin Method (Per Cent.).
English hay,	21.28	22.50
High-grown salt hay,	25.64	25.74
Branch grass,	24.65	26.43
Low meadow fox grass,	27.98	27.91
Buffalo gluten feed,	16.45	16.00
Lupine seeds,	9.42	9.64

With two exceptions the two methods show very closely agreeing results. We propose to still further compare these methods in the near future. The phloroglucin method, on account of its greater simplicity, is much to be preferred.

PART II.

(*a*) THE EFFECT OF NARROW AND WIDE RATIONS ON THE QUANTITY AND COST OF MILK AND BUTTER, AND ON THE COMPOSITION OF MILK.

J. B. LINDSEY, E. B. HOLLAND and GEO. A. BILLINGS.

RESULTS OF TWO EXPERIMENTS.

I. Definition: By narrow ration is meant one containing 4 to 5 times as much carbohydrates as protein (1 : 5); by wide ration one containing 8 to 10 times as much carbohydrates as protein (1 : 10).

II. The same amount of digestible matter in narrow rations produced from 11.8 to 12.9 per cent. more milk than did a like amount of digestible matter in wide rations; narrow rations also reduced the cost of production from 5 to 12 per cent.

III. The average cost of a quart of milk produced with the narrow rations was 1.81 cents, and with the wide rations 1.97 cents.

IV. The narrow rations produced over the wide rations practically the same relative increase in the amount of butter and the same decrease in the cost of production as in the case of the milk.

V. The narrow rations produced butter at a cost of 15.57 cents per pound, and the wide rations at a cost of 16.52 cents per pound.

VI. In Experiment I., with the narrow rations, the best cow produced 12.2 pounds of butter in a week, at a cost of 14 cents per pound; and the poorest cow produced 8.26 pounds, at a cost of 19.37 cents per pound. In the same experiment, with the wide ration, the best cow produced 9.52 pounds, at a cost of 16.67 cents per pound; and the poorest cow produced 7.28 pounds, at a cost of 18.88 cents per pound.

In Experiment II., on the narrow ration, the best cow produced 12.81 pounds of butter per week, at a cost for feed consumed of 11.66 cents; and the poorest cow 7.98 pounds, at a cost of 15.90 cents per pound. With the wide ration, the best cow produced 10.92 pounds per week, costing 12.71 cents; and the poorest cow 6.86 pounds, costing 16.21 cents per pound.

VII. In these two experiments narrow rations produced manure having 20 per cent. more fertilizing value than that produced by wide rations. In general, it can be said that narrow rations produce manure containing 10 to 15 per cent. more fertility than wide rations.

VIII. Neither the narrow nor wide ration produced any decided change in the composition of the milk.

IX. For total consumption of dry and digestible matter; total yields of milk, milk solids and fat; pounds of milk, milk solids and fat produced by 100 pounds of dry and digestible matter; and for digestible matter required to produce 100 pounds of milk, 1 pound of milk solids and 1 pound of butter,— see tables XII., XIII. and XIV., in rear of this report.

A. Methods employed in carrying out the Experiments.

Plan.

The experiments were two in number, and were conducted during the autumn and winter of 1895–96, with six cows. The animals were divided as evenly as possible into two lots, and the experiments were so arranged that in the first half of each experiment three of the cows were fed the narrow rations while the other three were receiving the wide rations; in the second half of the experiment the order was reversed. In this way the natural milk shrinkage as well as the natural change in the quality of the milk was equalized. In the first experiment the two halves each lasted twenty-six days, and at least seven days were allowed after the animals were placed upon the full ration before the actual test began. In Experiment II. the halves each lasted twenty-one days.

History of Cows.

NAME.	Breed.	Age.	Last Calf dropped.	MILK YIELD AT BEGINNING OF EXPERIMENTS. I.	II.
		Years.		Pounds.	Pounds.
I. Ada, ...	Grade Ayrshire, .	7	Oct. 1,	26	22
II. Una,*	Native, ...	10	Sept. 1,	22	-
II. Guernsey,† . .	Grade Guernsey, .	7	Dec. 1,	-	30
III. Bessie, . . .	Grade Ayrshire, .	7	Sept. 10,	27	26
IV. Beauty, . . .	Grade Jersey, . .	5	Sept. 15,	27	20
V. Red, ...	Grade Durham, . .	7	Oct. 8,	33	27
VI. Spot, ...	Grade Durham, . .	7	Oct. 8,	34	27

* Used in first experiment. † Used in second experiment.

The animals had been purchased in the neighborhood, at an average cost of $50 each, when fresh. They were better animals than the average, and most of them had been dry for several months before calving, so that they would naturally be able to do their best work during the two experiments now being described. None of the animals had been served at the beginning of the experiment, but they were allowed to take bull later. Most of them were served between the two halves of the first experiment.

Feeds and Feeding.

In the first experiment all of the cows were fed hay and sugar beets as coarse feeds. In the wide ration half, each cow had one pound more of hay daily than in the narrow ration half, in order to make up a like amount of total digestible daily nutrients. Chicago gluten meal and wheat bran were fed in the narrow ration, and corn meal and wheat bran in the wide ration. The hay was quite coarse, and consisted of Timothy, with an admixture of clover. Cow II. left a small quantity of the coarser portion in one half, which was deducted from the amount consumed in calculating the digestible daily nutrients eaten.

In the second experiment the coarse feeds consisted of hay, and millet and soy bean ensilage; the concentrated feeds in case of the narrow ration were bran, Chicago gluten meal and old-process linseed meal; and in case of the wide ration, wheat bran and corn meal. In this experiment the feeds were entirely consumed.

The feeds were very carefully weighed out, and given twice daily. Water was kept before the animals constantly, by means of the Buckley self-watering device. A cover swung upon hinges kept the feed from getting into the water. The animals very soon learned to lift the cover whenever they desired to drink.

Sampling the Feeds.

A small sample of the different grain feeds was taken daily, and preserved in glass-stoppered bottles; a sample of the hay was taken weekly, and likewise preserved; and at the end of each of the two halves of each experiment dry-matter determinations were made and samples preserved for analysis. In case of the sugar beets and ensilage, samples were taken weekly and tested for dry matter at once, and at the close of the experiment these several samples were mixed and preserved for analysis.

General Care.

The cows were milked twice daily, about five o'clock in the morning and five in the afternoon, always by the same attendant, who was a graduate of the college, and thoroughly trustworthy. The animals were carded daily, and allowed the run of a yard in pleasant weather. They were given plenty of stall room, and made as comfortable as possible. The wing of the stable in which they were confined contained no storage room, and each animal was allowed fully 1,200 cubic feet of air. The wing was heated with hot water, and kept at a temperature of 50 to 55 degrees F. during the winter months. Ventilation was secured by means of a shaft 8 by 15 inches, placed at the south end of the wing, running to within 1 foot of the floor, and extending 12 feet above the roof, terminating in a so-called Archimedean ventilator. In the shaft was placed a hot-water coil, to increase the draught. Air was admitted by means of windows opening into the barn, thus avoiding direct draughts. The windows were sufficient in number to keep the barn fully lighted.

Weighing the Animals.

The animals were weighed before feeding in the afternoon at the beginning and end of the experiment, and once a week during its continuance. It is recognized that this was not sufficient, and in experiments now being made the animals are weighed for three successive days at the beginning and end of the experiment and the same number of times weekly during its continuance.

Care of the Milk.

The milk was weighed at once after being drawn, on a Chatillon balance sensitive to two ounces. Composite samples were taken for five days of each week, the milk being preserved with the aid of bichromate of potash. In order to secure an average sample, it was poured from one pail to another three times, and then 10 c.c. removed with the aid of a pipette, an exact amount being taken at every milking. The glass jars containing the composite samples were kept tightly covered, and were gently rotated each day, to prevent any undue clotting of the cream.

Testing the Milk.

The tests were in all cases made in duplicate. The total solids were made either by the sand method or by use of the perforated disk filled with asbestos. The fat was determined by the gravimetric method, and in case of Experiment II. total nitrogen was estimated by the Kjeldahl method.

Experiment I.

DATES OF EXPERIMENT.	Narrow Ration.	Wide Ration.
October 24 through November 18, ...	Cows I., IV., VI.	Cows II., III., V.
November 28 through December 23, ...	Cows II., III., V.	Cows I., IV., VI.

Experiment II.

January 27 through February 16, ...	Cows I., II., VI.	Cows III., IV., V.
February 29 through March 20, ...	Cows III., IV., V.	Cows I., II., VI.

B. Rations consumed, and Their Effect on the Quantity and Cost of Milk and Butter.

Average Daily Rations fed to Six Cows (Pounds).

Experiment I.

CHARACTER OF RATION.	Wheat Bran.	Chicago Gluten.	Linseed Meal.	Corn Meal.	Hay.	Sugar Beets.	Millet and Bean Ensilage.
Narrow ration, ...	3	5.83	–	–	15.17	12	–
Wide ration, ...	3	–	–	5.83	16.17	12	–

Experiment II.

Narrow ration, ...	2.83	3 00	1.92	–	10.33	–	28.33
Wide ration, ...	1.92	–	–	5.83	10.33	–	28.33

Average Weight of Animals and Total Digestible Nutrients in Daily Rations (Pounds).

Experiment I.

CHARACTER OF RATION.	Weight of Animal.	Protein.	Fat.	Carbohydrates.	Total.	Nutritive Ratio.
Narrow ration, ...	941	3.07	.59	10.23	14.06	1 : 3.86
Wide ration, ...	938	1.46	.52	12.45	14.43	1 : 9.43

Experiment II.

Narrow ration, ...	899	2.85	.65	9.96	13.46	1 : 4.04
Wide ration, ...	890	1.45	.54	11.44	13.42	1 : 8.85

The difference between the two rations in Experiment I. consists in the fact that gluten meal high in protein was substituted for corn meal low in protein. In Experiment II.

gluten and linseed meals were substituted for corn meal. It might have been better had the coarse feeds been increased somewhat, in order to have raised the total digestible nutrients to 15 pounds daily. The animals, however, maintained very even average weights during both experiments. In both halves of each experiment the total digestible nutrients were practically the same.

TABLE I. — *Yield and Cost of Milk.*

Experiment I. 26 Days (6 Cows).

CHARACTER OF RATION.	Total Yield (Pounds).	AVERAGE DAILY YIELD. Quarts.	AVERAGE DAILY YIELD. Pounds.	Total Cost of Feed consumed.	Cost of Feed to produce a Quart of Milk (Cents).	Cost of Feed to produce 100 Pounds of Milk (Cents).
Narrow,	4241.5	12.65	27.2	$36.84	1.89	87.0
Wide,	3695.5	11.03	23.7	35.34	2.11	95.7
Increase narrow over wide ration,	546.0	1.62	3.5	1.50	—.22	—8.7
Percentage increase,	12.9	-	-	-	—11.70	-
Experiment II. 21 Days (6 Cows).						
Narrow,	3261.0	12.01	25.82	$26.27	1.74	80.6
Wide,	2877.0	10.58	22.73	24.43	1.83	84.9
Increase narrow over wide ration,	384.0	1.43	3.03	1.84	—.09	-
Percentage increase,	11.8	-	-	-	—5.20	-

The above table shows that the narrow rations produced from 11.8 to 12.9 per cent. more milk than did the wide rations, and that they reduced the cost of production from 5 to 12 per cent. At the end of Experiment II., six months after calving, the cows were averaging between 11 and 12 quarts of milk daily.* It was not the primary object of these two experiments to select the most economical feeds for milk production, but rather to note the effect of narrow *v.* wide rations on the *quality* of the milk. The figures, however, cannot fail to prove interesting to the milk producer.

---

* Cow No. 2, at the close of Experiment II., had been calved but three months.

TABLE II. — *Yield and Cost of Butter.*

Experiment I. 26 Days (6 Cows).

CHARACTER OF RATION.	Total Yield of Butter Fat.	Equivalent to Butter.	Average Daily Yield.	Average Weekly Yield.	Average Cost of Feed per Pound of Butter produced.
	Pounds.	Pounds.	Pounds.	Pounds.	Cents.
Narrow,	190.90	222.71	8.55	59.85	16.74
Wide,	164.87*	192.01	7.11	49.77	18.41
Increase narrow over wide ration,	26.03	30.70	1.44	10.08	—1.67
Percentage increase,	13.70	13.70	-	-	—10.00

Experiment II. 21 Days (6 Cows).

Narrow,	157.69	183.98	8.75	61.25	14.40
Wide,	144.56	168.64	8.01	56.07	14.64
Increase narrow over wide ration,	13.13	15.34	.74	5.18	—.24
Percentage increase,	8.30	8.30	-	-	—1.67

The figures tell the same story as they did in the yield of milk. On the narrow rations the cows produced 13.7 per cent. more butter in Experiment I. and 8.3 per cent. more in Experiment II. than they did on the wide rations. In Experiment I. the cost of feed per pound of butter produced was 16.74 cents for the narrow ration and 18.41 cents for the wide ration, showing that the narrow ration produced butter for 10 per cent. less per pound than did the wide ration. In Experiment II. the cost of feed per pound of butter produced was 14.57 cents for the narrow and 14.64 cents for the wide ration, showing a difference of but 1.67 per cent. in favor of the narrow ration.

It is of course impossible to state with accuracy the exact cost of feed required to produce a pound of butter, as so much depends upon the cost of feeds used, character of the cows, and the stage of lactation. The figures simply show what six of the better class of ordinary cows that had been well fed were able to do, during the first six months after calving.

---

* Cow V. (Red) during a portion of this period produced milk with but 2.85 per cent. of fat, and then suddenly increased to 4 per cent. The above figures include this cow's production on the basis of 4.05 per cent. fat for the entire period; otherwise the percentage increase of the butter in the narrow ration would be more than the percentage increase in the milk produced, which might lead to the supposition that the narrow ration had actually increased the percentage of fat in the milk, when really this sudden increase of fat was entirely independent of the influence of the feed.

TABLE III. — *Yield and Cost of Butter from Poorest and Best Cows.*

CHARACTER OF COW AND RATION.	EXPERIMENT I.			EXPERIMENT II.		
	Daily Yield.	Weekly Yield.	Cost of Feed per Pound.	Daily Yield.	Weekly Yield.	Cost of Feed per Pound.
	Pounds.	Pounds.	Cents.	Pounds.	Pounds.	Cents.
Best cow, narrow,	1.74	12.20	14.00	1.83	12.81	11.66
Poorest cow, narrow,	1.18	8.26	19.37	1.14	7.98	15.90
Best cow, wide,	1.36	9.52	16.67	1.56	10.92	12.71
Poorest cow, wide,	1.04	7.28	18.88	.98	6.86	16.21

In Experiment I. the best cow on the narrow ration produced 12.2 pounds of butter per week, at a cost for feed consumed of 14 cents per pound; while the poorest cow produced 8.26 pounds, at a cost of 19.37 cents per pound. In the same experiment on the wide ration one cow produced 9.52 pounds per week, costing 16.67 cents per pound; and another 7.28 pounds per week, costing 18.88 cents.

In Experiment II. the best yield with the narrow ration was 12.81 pounds of butter per week, costing for feed eaten 11.66 cents per pound; and the poorest yield was 7.98 pounds, costing 15.90 cents. In the same experiment on the wide ration the best yield was 10.92 pounds weekly, costing 12.71 cents per pound; and the least yield 6.86 pounds weekly, costing 16.21 cents per pound. One is enabled from the above figures to note both the influence of the cow and the cost of the daily ration upon the cost of the butter produced. The cow yielding 12.81 pounds weekly, at a cost of 11.66 cents per pound for food consumed, was a grade Guernsey, fresh at the time. Her general form and appearance would not indicate that she was more than a very ordinary cow. She produced about 14 quarts of milk daily when at her best, containing 5.3 per cent. of butter fat. Such facts as the above ought certainly to stimulate farmers to ascertain the amount and quality of the milk produced by their cows during a period of lactation. Only by such a course can the unprofitable cows be weeded out, and the herd brought to a higher standard. The scales and the Babcock tester are necessary; mere guess will not accomplish it.

TABLE IV. — *Approximate Estimate of the Amount and Value of Fertilizer Constituents in Excretions of the 6 Cows.*

CHARACTER OF RATIONS.	Nitrogen (Pounds).	Phosphoric Acid (Pounds).	Potash (Pounds).	Relative Values of Same.
Average of Experiments I. and II., narrow, .	153	35	79	$28 65
Average of Experiments I. and II., wide, . .	108	40	95	22 95
Percentage increased value of narrow over wide ration, .				$19 20

For the sake of comparison, by figuring the value of the nitrogen, phosphoric acid and potash contained in the feeds consumed (less 20 per cent. for the amount retained in the system or otherwise lost) by the market cost of these several ingredients per pound, it will be seen that the manure from the narrow ration has 20 per cent. more value than that from the wide ration. The cause of the increased value lies naturally in the increased amount of nitrogen present. In case of the rations fed in these experiments, the fact that the wide ration has more potash than the narrow is because gluten meal, which served to increase the protein, contains but minimum amounts of this ingredient. If cotton or linseed meal had been used in place of the gluten meal, the reverse would have been true. While the so-called narrow rations as used in these experiments were extreme ones, it might be said that narrow rations which contain from 2 to 2½ pounds of digestible protein in a day's feed, aside from their causing a 10 per cent. increase in the milk yield, furnish in addition a manure from 10 to possibly 15 per cent. more valuable than do wide rations.

While narrow rations will unquestionably produce more milk and butter than wide rations, the relative cost of the milk and butter produced by the two rations will depend upon the price of the concentrated feed stuffs. The markets, however, at the present time contain such a great variety of these products that the feeder can select those rich in protein at prices that will enable him to feed the narrow or so-called well-balanced rations to advantage.

In the closing remarks on this portion of the experiment, it is well to inquire what are to be considered as economical narrow rations. The German ration established so long ago by the late Emil von Wolff contained, for cows of 1,000 pounds weight, 2.5 pounds of digestible protein, .5 pounds of digestible fat and 13 pounds of digestible carbohydrates, with a proportion of protein to fat and carbohydrates of 1 to 5.4.

The writer is convinced that 2.5 pounds of digestible protein daily is amply sufficient, and seriously questions whether it is not too much. More than this amount, or even 2.5 pounds daily in the form of concentrated feed stuffs, if fed from eight to nine months each year, will soon tend to impair the milk-producing capacity of the cow. Some cows might be able to withstand such feeding longer than others. It might be advisable, for economic reasons, to feed as high as 3 pounds of digestible protein daily to average cows for two or three years, and then turn them into beef; but cows possessing more than ordinary merit should be differently handled. It should ever be kept in mind that it is far better to breed and select cows that possess extra milk and butter qualities than to attempt to attain those ends by extra amounts of concentrated feeds.

The amount of protein, as well as the amount of total digestible organic nutrients, that can be fed in the daily ration in order to produce milk and butter at low prices, and at the same time not impair the milk-producing organs by overwork, is still an uncertain quantity; and in order to secure more accurate information, taking into consideration American conditions, extended and carefully conducted investigations are necessary. Such experiments should be carried out only by those who can control all the conditions, who thoroughly understand the nature, handling and care of animals, and who have the time to give the experiments a close personal attention.

C. The Effect of Narrow and Wide Rations on the Quality of the Milk.

Many experiments have been published and many opinions expressed relative to the effects of single feeds and feed combinations on the quality of milk. The writer has briefly reviewed the most important of these experiments elsewhere.* W. H. Jordan † has recently also presented a most excellent review and critical examination of such experiments.

Practically all of the experiments thus far made have taught that feeds have but very little influence on the quality of milk. By "affecting the quality" is meant the increasing and decreasing of any or all of the solid constituents of the milk, such as casein, albumin, milk sugar, fat and ash. It is a commonly recognized fact that some feeds affect the flavor of milk, and to a slight extent its color, also possibly its acidity and alkalinity. It is possible that feeds and feed combinations rich in fat have a tendency to slightly increase the percentage of fat in the milk of some cows. Whether or not feeds rich in protein have a similar tendency, is still uncertain. It is probable that this increase is only of a temporary character, the milk gradually coming back to its normal condition. Animals very thin in flesh and insufficiently fed, if brought into good condition by proper feed, will probably show an increase in one or all of the solid constituents. This improvement will certainly not be very marked. It is possible that the improvement in the milk brought about by the more complete nourishment of a thin and insufficiently fed animal consists more in an improvement in the *quality* of the fat, or nitrogenous matter, than in increasing to any marked degree their actual percentages in the milk. The quality of milk varies, as is well known, during the different stages of lactation, but this is entirely independent of the influence of feed.

In conducting experiments of this character the investigator should be very careful that he is able to control all the conditions liable to in any way affect the results. The milk-producing organs are largely under the control of the nervous system, and any sudden change disturbing the nervous temperament of the animal, such as a sudden extreme change of temperature, an angry man, change of milkers, etc., is very likely to have an effect on the quality of her product. This can easily be observed by testing the milk daily and noting the variations, especially in the percentage of fat. Too short periods render such experiments valueless, as well as changing the entire daily character of the feed in two or three parts of a single experiment. No greater mistake can be made than in employing cheap, unreliable help. The results of many of the experiments thus far made along this line of investigation are of absolutely no value, because one or several improper influences have not been controlled by the experimenter.

---

* Twelfth report of Massachusetts Experiment Station, 1894.

† Agriculture of Maine, 1895, page 139.

In the two experiments which follow, the experimenter has sought as far as possible to prevent any influence other than the one desired to have any bearing on the results. The methods have been described under A. The complete feeding record of each cow will be found at the end of this article.

TABLE V. — *Showing Composition of the Milk.*

		COWS.																	
		ADA (1).						UNA * OR GUERNSEY † (2).						BESSIE (3).					
		Total Solids (Per Cent.).	Nitrogen (Per Cent.).	N.×6.25 = Nitrogenous Matter (Per Cent.).	Fat (Per Cent.).	Solids not Fat (Per Cent.).	Proportion of Fat to Solids not Fat	Total Solids (Per Cent.).	Nitrogen (Per Cent.).	N.×6.25 = Nitrogenous Matter (Per Cent.).	Fat (Per Cent.).	Solids not Fat (Per Cent.).	Proportion of Fat to Solids not Fat.	Total Solids (Per Cent.).	Nitrogen (Per Cent.).	N.×6.25 = Nitrogenous Matter (Per Cent.).	Fat (Per Cent.).	Solids not Fat (Per Cent.).	Proportion of Fat to Solids not Fat.
EXPERIMENT I.	Narrow ration, .	12.92	-	-	4.24	8.68	1:2.05	14.34	-	-	4.53	9.81	1:2.17	13.34	-	-	4.36	8.98	1:2.06
		12.83	-	-	4.07	8.76	1:2.15	14.50	-	-	4.68	9.82	1:2.10	13.37	-	-	4.36	9.01	1:2.07
		13.03	-	-	4.11	8.92	1:2.17	13.78	-	-	4.15	9.63	1:2.32	13.10	-	-	4.22	8.88	1:2.10
	Average, . .	12.93	-	-	4.14	8.79	1:2.12	14.21	-	-	4.45	9.75	1:2.20	13.27	-	-	4.31	8.96	1:2.08
	Wide ration, .	13.13	-	-	3.96	9.17	1:2.32	13.54	-	-	4.12	9.42	1:2.29	12.82	-	-	4.22	8.60	1:2.04
		13.30	-	-	4.20	9.10	1:2.17	13.87	-	-	4.35	9.52	1:2.19	12.60	-	-	4.22	8.36	1:1.97
		13.14	-	-	4.22	8.92	1:2.11	14.25	-	-	4.82	9.43	1:1.96	12.88	-	-	4.16	8.72	1:2.10
	Average, . .	13.19	-	-	4.13	9.06	1:2.20	13.89	-	-	4.43	9.46	1:2.14	12.77	-	-	4.21	8.56	1:2.04
EXPERIMENT II.	Narrow ration, .	13.28	.497	3.11	4.26	9.02	1:2.12	14.50	.511	3.19	5.35	9.15	1:1.71	13.58	.509	3.18	4.78	8.80	1:1.84
		13.11	.493	3.08	4.41	8.70	1:1.97	14.30	.503	3.14	5.39	8.91	1:1.67	13.36	.508	3.17	4.58	8.78	1:1.92
		13.24	.497	3.11	4.25	8.99	1:2.11	14.25	.501	3.13	5.25	9.00	1:1.71	13.55	.522	3.26	4.60	8.95	1:1.95
	Average, . .	13.21	.496	3.10	4.31	8.90	1:2.07	14.35	.505	3.15	5.33	9.02	1:1.70	13.50	.513	3.20	4.65	8.85	1:1.90
	Wide ration, .	13.41	.510	3.18	4.31	9.10	1:2.11	14.48	.526	3.29	5.30	9.18	1:1.73	13.98	.518	3.23	4.88	9.10	1:1.86
		13.49	.511	3.19	4.49	9.00	1:2.01	14.43	.499	3.11	5.53	8.90	1:1.61	14.21	.498	3.11	5.28	8.93	1:1.79
		13.50	.512	3.20	4.41	9.09	1:2.06	14.62	.508	3.17	5.63	8.99	1:1.60	14.05	.489	3.05	5.07	8.98	1:1.77
	Average, . .	13.47	.511	3.19	4.40	9.07	1:2.06	14.51	.511	3.19	5.49	9.02	1:1.65	14.08	.502	3.13	5.08	9.00	1:1.80

* In Experiment I.

† In Experiment II.

TABLE V. — *Concluded.*

		COWS.																	
		BEAUTY (4).						RED (5).						SPOT (6).					
		Total Solids (Per Cent.).	Nitrogen (Per Cent.).	N.×6.25 = Nitrogenous Matter (Per Cent.).	Fat (Per Cent.).	Solids not Fat (Per Cent.).	Proportion of Fat to Solids not Fat	Total Solids (Per Cent.).	Nitrogen (Per Cent.).	N.×6.25 = Nitrogenous Matter (Per Cent.).	Fat (Per Cent.).	Solids not Fat (Per Cent.).	Proportion of Fat to Solids not Fat.	Total Solids (Per Cent.).	Nitrogen (Per Cent.).	N.×6.25 = Nitrogenous Matter (Per Cent.).	Fat (Per Cent.).	Solids not Fat (Per Cent.).	Proportion of Fat to Solids not Fat
EXPERIMENT I.	Narrow ration,	13.98 14.68 14.80	- - -	- - -	4.75 5.19 5.32	9.23 9.49 9.48	1:1.94 1:1.83 1:1.78	12.68 12.86 12.58	- - -	- - -	4.02 4.18 3.90	8.66 8.68 8.68	1:2.15 1:2.08 1:2.23	14.15 14.17 14.68	- - -	- - -	5.00 4.81 5.30	9.15 9.36 9.38	1:1.83 1:1.94 1:1.77
	Average,	14.40	-	-	5.09	9.40	1:1.85	12.71	-	-	4.03	8.68	1:2.15	14.33	-	-	5.04	9.29	1:1.84
	Wide ration,	14.92 14.89 14.64	- - -	- - -	5.11 5.13 4.98	9.81 9.76 9.66	1:1.92 1:1.90 1:1.95	11.33 11.10 12.33	- - -	- - -	2.85 2.97 4.05	8.48 8.13 8.28	1:2.98 1:2.74 1:2.05	14.35 14.80 14.00	- - -	- - -	4.79 5.22 4.85	9.56 9.58 9.15	1:2.00 1:1.83 1:1.89
	Average,	14.82	-	-	5.07	9.75	1:1.92	12.33	-	-	4.05	8.28	1:2.05	14.38	-	-	4.95	9.43	1:1.91
EXPERIMENT II.	Narrow ration,	14.63 14.62 14.68	.563 .559 .572	3.52 3.49 3.57	5.19 5.17 5.24	9.44 9.45 9.44	1:1.82 1:1.82 1:1.80	13.33 13.11 13.40	.468 .522 .511	2.92 3.26 3.19	4.95 4.39 4.62	8.38 8.72 8.78	1:1.69 1:1.98 1:1.90	13.33 14.36 14.34	.579 .578 .588	3.62 3.61 3.67	4.89 4.82 4.75	8.44 9.54 9.59	1:1.72 1:1.98 1:2.02
	Average,	14.64	.565	3.53	5.20	9.44	1:1.81	13.28	.500	3.12	4.65	8.63	1:1.86	14.01	.582	3.63	4.82	9.19	1:1.91
	Wide ration,	14.92 14.95 14.80	.546 .547 .552	3.41 3.42 3.45	5.42 5.44 5.19	9.50 9.51 9.61	1:1.75 1:1.75 1:1.85	12.93 12.70 13.21	.455 .472 .468	2.84 2.95 2.92	4.37 4.21 4.62	8.56 8.49 8.59	1:1.96 1:2.02 1:1.86	14.67 14.96 14.81	.559 .579 .595	3.49 3.62 3.72	5.34 5.59 5.33	9.33 9.37 9.48	1:1.75 1:1.68 1:1.78
	Average,	14.89	.548	3.43	5.35	9.54	1:1.78	12.95	.465	2.90	4.40	8.55	1:1.95	14.81	.584	3.61	5.42	9.39	1:1.74

In judging the above results, it must not be forgotten that the entire lot of cows was not fed *at the same time* on either the wide or the narrow ration. For example, in Experiment I. cows I., IV. and VI. were first fed the narrow ration; while cows II., III. and V. were having at the same time the wide ration. It would be expected that cows I., IV. and VI. would naturally show slightly higher percentages on the wide ration, *because it was fed later;* and for a like reason cows II., III. and V. would show higher percentages on the narrow ration. In case of Cow V., on the wide ration, it has already been explained that the first two composite samples of milk show low solids, and less than 3 per cent. of fat. In the third sample both the solids and fat very noticeably increased. It is evident that this sudden change was not caused by feed; first, because the animal was in excellent flesh at the beginning of the experiment; and, second, because the change was a permanent one. The cow had been calved but a few weeks, and for some reason had not come to her average quality of milk. It was therefore considered advisable, in the wide ration, to omit in the average the first two analyses. With this exception, the first experiment shows very little variation in the quality of the milk. In the second experiment, cows I., II. and VI. were first fed the narrow ration, and cows III., IV. and V. first received the wide ration. All but Cow II. being somewhat advanced in the period of lactation, it is natural that at least cows I. and VI. should show slightly higher percentages with the wide ration, and cows III., IV. and V. with the narrow ration. This natural tendency is noticed in cows I., II., IV., V. and VI. One can therefore draw more reliable conclusions when the results from the six cows are averaged, thus eliminating as much as possible the error caused by natural shrinkage.

TABLE VI. — *Average Results from 6 Cows.*

Experiment I.

	Average Weight of Animals (Pounds).	Daily Digestible Nutrients consumed.					Composition of Milk.			
		Protein (Pounds).	Fat (Pounds).	Carbohydrates (Pounds).	Total Nutrients (Pounds).	Nutritive Ratio.	Total Solids (Per Cent.).	Nitrogenous Matter (Per Cent.)	Fat (Per Cent.).	Solids not Fat (Per Cent.).
Narrow ration, . .	941	3.07	.59	10.23	14.06	1:3.86	13.66	-	4.51	9.15
Wide ration, . . .	938	1.46	.52	12.45	14.43	1:9.43	13.56	-	4.47	9.09
Percentage increase narrow over wide.	-	-	-	-	-	-	+.73	-	+.89	+.66

Experiment II.

Narrow ration, . .	899	2.85	.65	9.96	13.46	1:4.04	13.83	3.29	4.83	9.00
Wide ration, . . .	890	1.45	.54	11.44	13.42	1:8.85	14.12	3.24	5.02	9.10
Percentage increase narrow over wide.	-	-	-	-	-	-	−2.10	+1.52	−3.93	−1.11

The average weights of the animals during both periods of each experiment are practically identical. In the first experiment the milk appears to have suffered no change in composition. In the second experiment the wide ration seems to have slightly increased the solids and fat and diminished the nitrogenous matter. This is more strikingly brought out in Table VII.

TABLE VII. — *Showing Percentages on Basis of 14 Per Cent. Solids.*

	Experiment I.		Experiment II.		
	Fat (Per Cent.).	Solids not Fat (Per Cent.).	Nitrogenous Matter (Per Cent)	Fat (Per Cent.).	Solids not Fat (Per Cent.).
Narrow ration, ...	4.62	9.38	3.33	4.88	9.11
Wide ration, ...	4.61	9.39	3.21	4.97	9.02
Percentage increase narrow over wide,	±	±	+3.60	−1.84	+ .99

In Table VII. it will be noticed that the wide ration, containing 1.45 pounds of digestible protein, .54 pound of digestible fat and 11.44 pounds of digestible carbohydrates, seemed to have produced a slight but noticeable increase in the percentage of fat; and the narrow ration, containing 2.85 pounds of digestible protein, .65 pound of digestible fat and 9.96 pounds of digestible carbohydrates, a slight increase in the total nitrogenous matter.

Recognizing the many serious difficulties in the way of securing results that will show *only* the influence of feed or feed constituents in the composition of milk, the writer would of course draw no positive conclusions, but simply present the figures as the results of two carefully conducted experiments along this line of investigation.

COMPLETE DATA OF EXPERIMENTS.

TABLE VIII. — *Total Feeds consumed, and Total Yield and Cost of Milk and Butter.*

Experiment I. Narrow Ration.

COW.	FEEDS CONSUMED.					MILK AND BUTTER PRODUCED.				COST OF MILK AND BUTTER.			
						MILK.		BUTTER.					
	Hay (Pounds).	Sugar Beets (Pounds).	Wheat Bran (Pounds).	Chicago Gluten Meal (Pounds).	Corn Meal (Pounds).	Total (Pounds).	Average Daily Yield (Pounds).	Total Butter Fat (Pounds).	Equal to Butter (Pounds).	Total Cost of Feeds consumed.	Cost of Feed per 100 Pounds of Milk (Cents).	Cost per Pound Butter Fat (Cents).	Cost per Pound Butter (Cents).
Ada,	312	312	78	130	-	655.2	25.2	27.13	31.65	$5 28	80.6	19.46	16.68
Una,	364	312	78	156	-	592.4	22.8	26.36	30.76	5 96	100.6	22.61	19.37
Bessie,	390	312	78	156	-	813.6	31.3	35.07	40.91	6 16	75.7	17.56	15.05
Beauty,	468	312	78	156	-	631.2	24.3	32.13	37.48	6 74	106.8	20.97	17.99
Red,	416	312	78	156	-	777.6	29.9	31.34	36.56	6 35	81.6	20.26	17.37
Spot,	416	312	78	156	-	771.5	29.7	38.87	45.35	6 35	82.4	16.32	14.00

Wide Ration.

COW.	Hay (Pounds).	Sugar Beets (Pounds).	Wheat Bran (Pounds).	Chicago Gluten Meal (Pounds).	Corn Meal (Pounds).	Total (Pounds).	Average Daily Yield (Pounds).	Total Butter Fat (Pounds).	Equal to Butter (Pounds).	Total Cost of Feeds consumed.	Cost of Feed per 100 Pounds of Milk (Cents).	Cost per Pound Butter Fat (Cents).	Cost per Pound Butter (Cents).
Ada,	338	312	78	-	130	559.3	21.5	23.10	26.95	$5 09	90.9	22.03	18.88
Una,	390	312	78	-	156	559.4	21.5	24.78	28.91	5 70	101.9	23.00	19.71
Bessie,	416	312	78	-	156	719.2	27.7	30.28	35.33	5 89	81.9	19.45	16.67
Beauty,	494	312	78	-	156	522.5	20.1	26.48	30.89	6 48	124.1	24.50	21.00
Red,	442	312	78	-	156	761.7	29.3	25.13	29.30	6 09	80.0	24.26	20.80
Spot,	442	312	78	-	156	573.9	22.1	28.41	33.14	6 09	106.1	21.44	18.38

TABLE IX. — *Total Feeds consumed, and Total Yield and Cost of Milk and Butter.*

Experiment II. Narrow Ration.

COW.	FEEDS CONSUMED.					MILK AND BUTTER PRODUCED.				COST OF MILK AND BUTTER.			
						MILK.		BUTTER.					
	Hay (Pounds).	Millet and Soy-bean Ensilage (Pounds).	Wheat Bran (Pounds).	Chicago Gluten Meal (Pounds).	Old-process Linseed Meal (Pounds).	Total (Pounds).	Average Daily Yield (Pounds).	Total Butter Fat (Pounds).	Equal to Butter (Pounds).	Total Cost of Feeds consumed.	Cost of Feed per 100 Pounds of Milk (Cents).	Cost per Pound Butter Fat (Cents).	Cost per Pound Butter (Cents).
Ada,	189	420	42	63	31.5	474.9	22.6	20.47	23.88	$3 68	76.4	17.70	15.90
Guernsey,	210	630	63	63	42	617.4	29.4	32.91	38.39	4 48	72.6	13.62	11.66
Bessie,	210	630	63	63	42	593.2	28.2	27.58	32.20	4 48	75.5	16.23	13.91
Beauty,	220	630	63	63	42	459.4	21.9	23.89	27.87	4 56	99.3	19.10	16.34
Red,	220	630	63	63	42	556.8	26.5	25.90	30.21	4 56	81.9	17.60	15.10
Spot,	220	630	63	63	42	559.0	26.6	26.94	31.43	4 56	81.5	16.93	14.52

Wide Ration.

COW.	Hay (Pounds).	Millet and Soy-bean Ensilage (Pounds).	Wheat Bran (Pounds).	*Corn Meal.*	Old-process Linseed Meal (Pounds).	Total (Pounds).	Average Daily Yield (Pounds).	Total Butter Fat (Pounds).	Equal to Butter (Pounds).	Total Cost of Feeds consumed.	Cost of Feed per 100 Pounds of Milk (Cents).	Cost per Pound Butter Fat (Cents).	Cost per Pound Butter (Cents).
Ada,	189	420	31.5	105	-	402.1	19.5	17.70	20.65	$3 34	83.1	18.87	16.21
Guernsey,	210	630	42	126	-	512.7	24.4	28.15	32.84	4 17	81.3	14.84	12.71
Bessie,	210	630	42	126	-	508.1	24.2	25.81	30.11	4 17	82.1	16.16	13.85
Beauty,	220	630	42	126	-	439.7	20.9	23.53	27.45	4 25	96.6	18.90	15.51
Red,	220	630	42	126	-	553.6	26.4	24.37	28.42	4 25	76.7	17.41	15.00
Spot,	220	630	42	126	-	461.3	22.0	25.00	29.17	4 25	92.2	17.00	14.55

TABLE X. — *Daily Feeds consumed.*

Experiment I. Narrow Ration.

COW.	FEEDS CONSUMED (POUNDS) PER DAY.					Dry Matter consumed per Day (Pounds).	Digestible Protein (Pounds).	Digestible Fat (Pounds).	Digestible Carbohydrates (Pounds).	Total Digestible Nutrients (Pounds).	Nutritive Ratio of Ration.	Weight at Beginning and End of Experiment (Pounds).	Average Weight (Pounds).
	Hay.	Sugar Beets.	Wheat Bran.	Chicago Gluten Meal.	Corn Meal.								
Ada,	12	12	3	5	-	19.24	2.66	.51	8.85	12.02	1:3.80	788-810	794
Una,	14	12	3	6	-	21.85	3.08	.58	10.00	13.66	1:3.72	870-900	905
Bessie,	15	12	3	6	-	22.75	3.12	.59	10.39	14.10	1:3.80	869-874	860
Beauty,	18	12	3	6	-	25.41	3.24	.63	11.59	15.46	1:4.03	1,037-1,055	1,038
Red,	16	12	3	6	-	23.59	3.16	.61	10.77	14.54	1:3.90	1,040-1,058	1,061
Spot,	16	12	3	6	-	23.65	3.16	.61	10.79	14.56	1:3.90	1,000-1,008	987
Wide Ration.													
Ada,	13	12	3	-	5	20.13	1.29	.45	10.68	12.42	1:9.16	805-801	807
Una,	14.50	12	3	-	6	22.30	1.40	.51	11.91	13.82	1:9.40	394-884	888
Bessie,	16	12	3	-	6	23.67	1.46	.53	12.53	14.52	1:9.50	890-862	867
Beauty,	19	12	3	-	6	26.22	1.57	.56	13.57	15.70	1:9.54	1,045-1,033	1,044
Red,	17	12	3	-	6	24.55	1.50	.54	12.93	14.97	1:9.52	1,020-1,038	1,025
Spot,	17	12	3	-	6	24.48	1.50	.54	12.88	14.92	1:9.49	1,010-982	995

TABLE XI. — *Daily Feeds consumed.*

Experiment II. Narrow Ration.

COW.	Feeds consumed Daily (Pounds).						Dry Matter consumed Daily (Pounds).	Digestible Matter consumed Daily (Pounds).				Nutritive Ratio of Ration.	Weight at Beginning and End of Experiment (Pounds).	Average Weight (Pounds).
	Hay.	Millet and Soy-bean Ensilage.	Wheat Bran.	Chicago Gluten Meal.	Linseed Meal.	Corn Meal.		Protein.	Fat.	Carbohydrates.	Total Nutrients.			
Ada,	9	20	2	3	1.5	-	17.43	2.41	.52	8.05	10.98	1:3.9	770-762	763
Guernsey,	10	30	3	3	2	-	21.49	2.89	.66	9.88	13.43	1:4.0	862-860	861
Bessie,	10	30	3	3	2	-	22.15	2.93	.67	10.21	13.81	1:4.0	835-822	828
Beauty,	11	30	3	3	2	-	23.05	2.98	.68	10.65	14.31	1:4.1	995-975	981
Red,	11	30	3	3	2	-	23.05	2.98	.68	10.65	14.31	1:4.1	1,022-1,022	1,017
Spot,	11	30	3	3	2	-	22.37	2.98	.67	10.32	13.97	1:4.1	948-940	943
Wide Ration.														
Ada,	9	20	1.5	-	-	5	17.63	1.20	.44	9.58	11.22	1:8.90	775-770	772
Guernsey,	10	30	2	-	-	6	21.80	1.50	.56	11.74	13.80	1:8.76	850-835	838
Bessie,	10	30	2	-	-	6	21.12	1.44	.55	11.41	13.40	1:8.88	814-835	824
Beauty,	11	30	2	-	-	6	22.00	1.49	.56	11.85	13.90	1:8.89	970-966	958
Red,	11	30	2	-	-	6	22.00	1.49	.56	11.85	13.90	1:8.89	1,011-1,007	1,004
Spot,	11	30	2	-	-	6	22.70	1.55	.57	12.18	14.30	1:8.78	940-945	942

TABLE XII. — *Showing Total Amount of Dry and Digestible Matter consumed, and Total Milk Products produced.*

Experiment I.

CHARACTER OF RATION.	Dry Matter consumed (Pounds).	Digestible Matter consumed (Pounds).	Milk produced (Pounds).	Milk Solids produced (Pounds).	Milk Fat produced (Pounds).
Narrow, ...	3,549.0	2,193.4	4,241.5	579.4	191.3
Wide, ...	3,675.4	2,251.1	3,695.5	501.1	165.2

Experiment II.

CHARACTER OF RATION.	Dry Matter consumed (Pounds).	Digestible Matter consumed (Pounds).	Milk produced (Pounds).	Milk Solids produced (Pounds).	Milk Fat produced (Pounds).
Narrow, ...	2,721.6	1,696.0	3,261.0	451.0	157.5
Wide, ...	2,671.2	1,691.0	2,877.0	406.2	144.4

TABLE XIII. — *Showing for Every 100 Pounds of Dry and Digestible Matter consumed, Amounts of Milk, Milk Solids and Milk Fat produced.*

Narrow Ration.

ONE HUNDRED POUNDS.	EXPERIMENT I.			EXPERIMENT II.		
	Milk (Pounds).	Milk Solids (Pounds).	Fat (Pounds).	Milk (Pounds).	Milk Solids (Pounds).	Fat (Pounds).
Dry matter produced, ...	119.51	16.32	5.39	119.8	16.6	5.8
Digestible matter produced, . . .	193.41	26.42	8.72	192.3	26.6	9.3

Wide Ration.

ONE HUNDRED POUNDS.	EXPERIMENT I.			EXPERIMENT II.		
	Milk (Pounds).	Milk Solids (Pounds).	Fat (Pounds).	Milk (Pounds).	Milk Solids (Pounds).	Fat (Pounds).
Dry matter produced, ...	100.28	13.74	4.48	107.7	15.4	5.40
Digestible matter produced, . . .	164.16	22.28	7.34	170.1	24.0	8.54

TABLE XIV. — *Pounds of Digestible Matter required to produce 100 Pounds of Milk, a Pound of Milk Solids and a Pound of Butter.*

Narrow Ration.

POUNDS REQUIRED OF —	EXPERIMENT I.			EXPERIMENT II.		
	TO PRODUCE —			TO PRODUCE —		
	100 Pounds Milk.	One Pound Milk Solids.	One Pound Butter.	100 Pounds Milk.	One Pound Milk Solids.	One Pound Butter.
Digestible matter, ...	51.7	3.78	9.83	52.0	3.76	9.2

Wide Ration.

POUNDS REQUIRED OF —	100 Pounds Milk.	One Pound Milk Solids.	One Pound Butter.	100 Pounds Milk.	One Pound Milk Solids.	One Pound Butter.
Digestible matter, ...	60.9	4.49	11.68	58.8	4.16	10.04

TABLE XV. — *Composition of Feeds (Dry Matter).*

Experiment I.

	Hay (Per Cent.).	Digestion Coefficients.	Sugar Beets (Per Cent.).	Digestion Coefficients.	Millet and Soy-bean Ensilage (Per Cent.).	Digestion Coefficients.	Wheat Bran (Per Cent.).	Digestion Coefficients.	Chicago Gluten Meal (Per Cent.).	Digestion Coefficients.	Old-process Linseed Meal (Per Cent.).	Digestion Coefficients.	Corn Meal (Per Cent.).	Digestion Coefficients.	Waste (Cow II., Wide Ration).*
Ash, ...	6.02	-	9.16	-	-	-	5.77	-	1.16	-	-	-	1.43	-	5.10
Fiber, ...	33.13	47	8.58	-	-	-	11.63	22	3.12	-	-	-	2.06	-	43.66
Fat, ...	2.65	53	.63	-	-	-	5.64	71	5.96	93	-	-	4.46	92	1.58
Protein, ...	9.73	45	8.65	62	-	-	19.20	78	42.73	89	-	-	11.36	60	6.21
Extract matter, ...	48.47	60	72.98	98	-	-	57.76	68	47.03	93	-	-	80.69	93	43.45

Experiment II.

	Hay (Per Cent.).	Digestion Coefficients.	Sugar Beets (Per Cent.).	Digestion Coefficients.	Millet and Soy-bean Ensilage (Per Cent.).	Digestion Coefficients.	Wheat Bran (Per Cent.).	Digestion Coefficients.	Chicago Gluten Meal (Per Cent.).	Digestion Coefficients.	Old-process Linseed Meal (Per Cent.).	Digestion Coefficients.	Corn Meal (Per Cent.).	Digestion Coefficients.	Waste (Cow II., Wide Ration).*
Ash, ...	5.32	-	-	-	10.55	-	6.41	-	.90	-	4.94	-	1.27	-	-
Fiber, ...	32.27	60	-	-	36.07	69	11.03	22	3.63	-	7.26	50	2.44	-	-
Fat, ...	2.72	49	-	-	4.25	72	5.62	71	6.06	93	7.05	89	4.12	92	-
Protein, ...	9.21	59	-	-	12.01	57	18.87	78	39.75	89	41.99	89	11.36	60	-
Extract matter, ...	50.48	59	-	-	37.12	59	58.07	68	49.66	93	38.76	78	80.80	93	-

* Amounting to 14.75 pounds and containing 85 per cent. of dry matter.

TABLE XVI. — *Dry Matter Determinations.*

Experiment I.

	Hay (Per Cent.).	Sugar Beets (Per Cent.).	Millet and Soy-bean Ensilage (Per Cent.).	Wheat Bran (Per Cent).	Chicago Gluten Meal (Per Cent.).	Old-process Linseed Meal (Per Cent.).	Corn Meal (Per Cent.).
October 24 to November 19, .	87.5	13.00	-	88.3	91.0	-	87.7
November 28 to December 24, .	87.0	14.70	-	88.6	91.0	-	87.7
Experiment II.							
January 27 to February 17, .	88 0	-	18.4	88.0	91.0	90.0	84.5
February 29 to March 21, . .	91.0	-	19.7	88.0	91.0	90.0	84.5

Market Cost of Feed Stuffs per Ton.

	Experiment I.	Experiment II.
Hay, ...	$15 00	$15 00
Sugar beets, ...	5 00	-
Millet and soy-bean ensilage, ...	-	4 00
Wheat bran, ...	17 00	16 00
Chicago gluten meal, ...	23 00	22 00
Linseed meal, ...	-	22 00
Corn meal, ...	17 00	16 00

FEEDING EXPERIMENTS WITH PIGS.

(*b*) RICE MEAL *v.* CORN MEAL.

EXPERIMENT I. — *Nov. 12, 1895, to Feb. 11, 1896.*

Results.

Three pigs fed rice meal and skim-milk each showed an average weight of 67 pounds at the beginning of the experiment and 195.2 pounds at the end of the experiment; the three fed corn meal and skim-milk each showed an average weight of 65 pounds at the beginning and 193.5 pounds at the end of the experiment.

The rice meal lot consumed during the experiment 3,519 pounds of skim-milk (1,614 quarts), together with 867 pounds of rice meal, and gained 385 pounds of live weight, equal to 298 pounds of dressed weight; the corn meal lot consumed like quantities of milk and corn meal, and gained 385 pounds of live weight, equal to 309 pounds of dressed weight.

The rice meal lot consumed 1,118.64 pounds of dry matter and the corn meal lot 1,105.65 pounds of dry matter.

The rice meal lot required 2.91 pounds of dry matter to produce 1 pound of live weight and 3.77 pounds to produce 1 pound of dressed weight; the corn meal lot required 2.91 pounds of dry matter to produce 1 pound of live weight and 3.59 pounds to produce 1 pound of dressed weight.

The average daily gain in live weight of each pig in both the rice and corn meal lots was 1.41 pounds.

The three pigs fed rice meal showed an average shrinkage of 22.64 per cent. in dressing; the corn meal fed pigs shrank 20 per cent.

The above results indicate that a good quality of rice meal has a feeding value equal to a similar quality of corn meal.

With grain at $18 per ton and dressed pork at 5 cents per pound, skim-milk returned ½ of a cent per quart, or 23 cents per 100 pounds; with the same price for grain and dressed pork at 6 cents per pound, skim-milk would return 31.5 cents per 100 pounds.

With grain at $18 per ton and skim-milk at 15 cents per 100 pounds, live weight would cost 2.88 cents per pound and dressed weight 3.66 cents. If skim-milk were reckoned at 25 cents per 100 pounds, live weight would cost 4 cents per pound and dressed weight 5 cents per pound.

Details of the Experiment.

The object of the experiment was to compare the nutritive effect of rice meal with corn meal when fed in connection with skim-milk. Six pigs, grade Chester White, all out of the same litter, were selected. They were received October 15, when six weeks old, and kept for a month before beginning the experiment. Before starting the experiment each pig was placed in a separate pen, of about 100 feet area. The pens were separated by heavy galvanized wire, thus securing good ventilation, and allowing at the same time the animals to see each other. While they had no outdoor run, the pens were large, the room airy and well lighted, and the constant good health of the animals indicated no disturbing influences. Only in very severe weather did the temperature in the building fall a little below freezing.

Feeding.—The animals were fed three times daily, the slightly warmed milk being measured, and the grain ration for the twenty-four hours accurately weighed. The pigs were each given from 5 to 6 quarts of milk daily. At the beginning of the experiment 4 ounces of grain were given with each quart of milk; and the amount increased from time to time, to suit the appetites of the animals. The feed was consumed during the entire time, without a single refusal.

Feeds. — The skim-milk was tested occasionally, and 9.75 per cent. of solids were used in calculating the amount of dry matter it contained. Rice meal is fed and highly prized in Europe. It is occasionally found in our markets, but the present low price of corn meal excludes it. In preparing rice for human consumption, various mechanical processes are employed. After the hull is removed, the rice is brought into mortars holding from 4 to 6 bushels each and pounded, to remove the yellow, gluey covering of the grain and give it the creamy color so much desired. This pounding really removes the chaff and some of the flour, and leaves the grain but little broken. The rice is then polished to give it a pearly lustre, which is effected by friction of the grains of rice against tanned moose hide. That portion rubbed off is termed rice polish. The chaff and flour above referred to, and in some cases the polish also, are mixed and sold as rice meal for cattle feeding.

Composition.

[Figures equal percentages or pounds per 100.]

	Rice Meal.	Corn Meal.
Water,	10.50	12.00
Ash,	7.67	1.42
Fiber,	5.03	1.84
Fat,	12.10	3.34
Protein,	12.95	9.68
Extract matter,	51.75	71.72

The above feeds have the same type of composition, being comparatively low in protein and high in carbohydrates. They both may be termed heat-producing and fattening feeds. The rice meal contains more fat and less extract or starchy matter than the corn meal.

Data of the Experiment (Nov. 12, 1895, to Feb. 12, 1896).

LOT I. — *Rice Meal.*

NUMBER OF PIG.	SKIM-MILK CONSUMED.			GRAIN CONSUMED.			Weight at Beginning of Experiment (Pounds).	Weight at End of Experiment (Pounds).	Gain in Live Weight (Pounds).	Daily Gain in Live Weight (Pounds).	Loss of Weight in Dressing (Per Cent.).	Computed Dressed Weight at Beginning of Experiment (Pounds).	Dressed Weight at End of Experiment (Pounds).	Gain in Dressed Weight (Pounds).	Dry Substance used to produce One Pound Live Weight (Pounds).	Dry Substance used to produce One Pound Dressed Weight (Pounds).
	Quarts.	Pounds.	Dry Matter (Pounds).	Corn Meal (Pounds).	Rice Meal (Pounds).	Dry Matter (Pounds).										
I,	538	1,172.8	114.35	-	288.87	258.5	67.25	187.00	119.75	1.32	22.86	51.88	144.25	92.37	3.11	4.04
II.,	538	1,172.8	114.35	-	288.87	258.5	67.25	199.25	132.00	1.45	23.46	51.47	152.50	101.03	2.82	3.69
III.,	538	1,172.8	114.35	-	288.87	258.5	67.00	200.25	132.25	1.46	21.59	52.53	157.00	104.47	2.80	3.57
Total,	1,614	3,518.5	343.05	-	866.60	775.6	201.50	586.50	385.00	4.23	-	155.88	453.75	297.81	-	-
Average per pig,	538	1,172.8	114.35	-	288.87	258.5	67.00	195.20	128.30	1.41	22.64	51.96	151.28	99.37	2.91	3.77

LOT II. — *Corn Meal.*

NUMBER OF PIG.	Quarts.	Pounds.	Dry Matter (Pounds).	Corn Meal (Pounds).	Rice Meal (Pounds).	Dry Matter (Pounds).	Weight at Beginning of Experiment (Pounds).	Weight at End of Experiment (Pounds).	Gain in Live Weight (Pounds).	Daily Gain in Live Weight (Pounds).	Loss of Weight in Dressing (Per Cent.).	Computed Dressed Weight at Beginning of Experiment (Pounds).	Dressed Weight at End of Experiment (Pounds).	Gain in Dressed Weight (Pounds).	Dry Substance used to produce One Pound Live Weight (Pounds).	Dry Substance used to produce One Pound Dressed Weight (Pounds).
I.,	538	1,172.8	114.35	288.87	-	254.20	67.00	192.50	125.50	1.38	19.74	53.77	154.50	100.73	2.94	3.66
II.,	538	1,172,8	114.35	288.87	-	254.20	58.75	184.50	125.75	1.41	20.73	46.57	146.25	99.68	2.93	3.70
III.,	538	1,172.8	114.35	288.87	-	254.20	69.25	203.50	134.25	1.48	19.41	55.81	164.00	108.19	2.74	3.41
Total,	1,614	3,518.5	343.05	866.60	-	762.60	195.00	580.50	385.50	4.27	-	156.15	464.75	308.60	-	-
Average per pig,	538	1,172.8	114.35	288.87	-	254.20	65.00	193.50	128.50	1.42	19.96	52.05	154.92	102.90	2.90	3.59

Additional Data.

In order to throw light on the price returned for skim-milk and the cost of feed required to produce a pound of live and dressed weight, the following additional data is presented, and the amount of feed consumed is reckoned from October 15, when the pigs were received, to February 12, when they were slaughtered. The results below are based on the entire lot of six pigs.

	Quarts.	Pounds.
Total milk consumed by six pigs, ...	4,092	8,921
Total grain consumed by six pigs, ...	-	1,920
Live weight actually gained, ...	-	968
Dressed weight actually gained, ...	-	762

PRICE RETURNED FOR SKIM-MILK.	When Corn Meal sells at $18 per Ton and Dressed Pork at —				When Corn Meal sells at $24 per Ton and Dressed Pork at —			
	Five Cents.	Six Cents.	Seven Cents.	Eight Cents.	Five Cents.	Six Cents.	Seven Cents.	Eight Cents.
Per quart (fraction of cent), ...	.50	.69	.87	1.06	.36	.54	.73	.91
Per 100 pounds (cents),	23.00	31.50	40.00	48.50	16.00	25.00	33.00	42.00

The pigs were six weeks old when they were received, and weighed about 33 pounds each. When slaughtered they averaged 194.5 pounds each. The pigs made a rapid growth, and the results are fully as favorable as could be hoped for.

Cost of Feed per Pound of Growth produced (Cents).

	Live Weight.	Dressed Weight.
When corn meal costs $18 per ton and milk ¼ cent per quart, .	2.88	3.66
When corn meal costs $18 per ton and milk ½ cent per quart, .	4.00	5.00
When corn meal costs $24 per ton and milk ¼ cent per quart, .	3.48	4.43
When corn meal costs $24 per ton and milk ½ cent per quart, .	4.55	5.80

(c) OAT FEED v. CORN MEAL FOR PIGS.

EXPERIMENT II. — *March 29 to June 30, 1896.*

Results.

Four pigs fed oat feed and skim-milk each showed an average weight of 42.56 pounds at the beginning and 136.75 pounds at the end of the experiment; the two fed corn meal and milk showed an average weight of 45.25 pounds at the beginning and 157.70 pounds at the end of the experiment.

The oat feed lot consumed during the experiment 5,389 pounds of skim-milk (2,474 quarts), together with 869 pounds of oat feed, and gained 376.75 pounds of live weight, an average gain of 94.19 pounds each; the corn meal lot consumed 2,694.5 pounds of milk (1,236 quarts), together with 435 pounds of corn meal, and gained 225.25 pounds, or an average gain of 112.62 pounds.

The oat feed lot consumed 1,305.96 pounds of dry matter and required 3.47 pounds of dry matter to produce a pound of live weight; the corn meal lot consumed 645.1 pounds of dry matter and required 2.86 pounds of dry matter to produce a pound of live weight.

The oat feed lot showed an average daily gain of 1.03 pounds in live weight, and the corn meal lot a daily gain of 1.22 pounds in live weight.

The present experiment shows that only 83.6 per cent. as much pork was produced with oat feed as with an equal weight of corn meal, or 100 pounds of corn meal were equal to 120 pounds of oat feed.

With corn meal at $18 per ton, oat feed at $16 per ton and dressed pork at 5 cents per pound, skim-milk returned $\frac{1}{3}$ of a cent per quart, or 15.6 cents per 100 pounds in case of the entire lot of six pigs.

With the same price for grain and skim-milk reckoned at $\frac{1}{4}$ cent per quart, live weight would cost 3.34 cents and dressed weight 4.3 cents per pound. Further details concerning prices will be found in the description of the experiment.

Details of Experiment II.

The object of this experiment was to compare the nutritive effect of corn meal with oat feed. Six grade Chester White pigs, all from the same litter, were used. The pigs were kept in the same pens and handled in the same way as described in the previous experiment. They had been in the pens over a month before the experiment began.

Feeding.— The pigs were each fed at the beginning 5 quarts of milk together with 3 ounces of meal to each quart of milk, and increased in this proportion till 8 quarts of milk were fed; the grains were then still further increased from time to time to satisfy the appetites of the animals.

Feeds.— The skim-milk and corn meal were of the same average quality as reported in the previous experiment. Oat feed is the refuse from factories engaged in the preparation of oat meal for human consumption. It consists of the poor oats, oat hulls and some of the bran and starch which are removed in the process of manufacture. It is, as the corn meal, a heat-producing rather than a flesh-forming feed. Oat feed varies very much in composition, and consequently in feeding value. The sample used may be considered an average one.

Composition.

[Figures equal percentages or pounds per 100.]

	Oat Feed.	Corn Meal.
Water,	10.00	12.00
Ash,	5.00	1.42
Fiber,	14.75	1.84
Fat,	3.72	3.34
Protein,	12.19	9.68
Extract matter,	54.34	71.72

The presence of the high percentage of fiber in the oat feed is indicative of a considerable amount of hulls.

Data of the Experiment (March 29 to June 30, 1896).

LOT I. — *Oat Feed.*

NUMBER OF PIG.	SKIM-MILK CONSUMED.			GRAINS CONSUMED.			Live Weight at Beginning of Experiment (Pounds).	Live Weight at End of Experiment (Pounds).	Total Gain in Live Weight (Pounds).	Daily Gain in Live Weight (Pounds).	Dry Matter needed to produce a Pound of Live Weight (Pounds).
	Quarts.	Pounds.	Dry Matter (Pounds).	Oat Feed (Pounds).	Corn Meal (Pounds).	Dry Matter (Pounds).					
I.,	618	1,347.24	131.36	217.3	–	195.13	46.75	140.75	94.00	1.02	3.47
II.,	618	1,347.24	131.36	217.3	–	195.13	35.75	121.75	86.00	.94	3.89
III.,	618	1,347.24	131.36	217.3	–	195.13	43.50	143.75	100.25	1.09	3.26
IV.,	618	1,347.24	131.36	217.3	–	195.13	44.25	140.75	96.50	1.05	3.38
Total,	2,472	5,388.96	525.44	869.2	–	780.52	170.25	547.00	376.75	–	–
Average per pig,	618	1,347.24	131.36	217.3	–	195.13	42.56	136.75	94.19	1.03	3.50

LOT II. — *Corn Meal.*

NUMBER OF PIG.	Quarts.	Pounds.	Dry Matter (Pounds).	Oat Feed (Pounds).	Corn Meal (Pounds).	Dry Matter (Pounds).	Live Weight at Beginning of Experiment (Pounds).	Live Weight at End of Experiment (Pounds).	Total Gain in Live Weight (Pounds).	Daily Gain in Live Weight (Pounds).	Dry Matter needed to produce a Pound of Live Weight (Pounds).
V.,	618	1,347.24	131.36	–	217.3	191.20	43.25	154.57	111.50	1.21	2.89
VII.,	618	1,347.24	131.36	–	217.3	191.20	47.25	160.75	113.75	1.24	2.84
Total,	1,236	2,694.48	262.72	–	434.6	382.40	90.50	315.50	225.25	–	–
Average per pig,	618	1,347.24	131.36	–	217.3	191.20	45.25	157.70	112.62	1.22	2.86

Additional Data.

In order to show the price returned for skim-milk and the cost of feed required to produce a pound of live and dressed weight, the additional data is presented for the six pigs : —

	Quarts.	Pounds.
Total milk consumed by six pigs, ...	3,708	8,083.5
Total oat feed consumed by six pigs, ...	-	869.0
Total corn meal consumed by six pigs, ...	-	435.0
Live weight actually gained, ...	-	602.0
Dressed weight calculated, ...	-	470.0

PRICE RETURNED FOR SKIM-MILK.	With Oat Feed at $16 per Ton, Corn Meal at $18 per Ton and Dressed Pork at —				With Oat Feed at $21 per Ton, Corn Meal at $24 per Ton and Dressed Pork at —			
	Five Cents.	Six Cents.	Seven Cents.	Eight Cents.	Five Cents.	Six Cents.	Seven Cents.	Eight Cents.
Per quart (fraction of cent), . . .	.34	.47	.60	.72	.25	.37	.50	.62
Per 100 pounds (cents),	15.60	21.40	27.00	33.00	11.00	17.00	23.00	29.00

The pigs did not grow as rapidly as in the first experiment, and consequently the returns are below those obtained with the previous lot. The animals seemed inferior, and unable to turn the feed into rapid growth. The above figures are more nearly what might be expected by the average farmer.

Cost of Feed per Pound of Growth produced (*Cents*).

	Live Weight.	Dressed Weight.
With grain prices at $16 and $18 and milk at ¼ cent per quart, .	3.34	4.30
With grain prices at $16 and $18 and milk at ½ cent per quart, .	4.88	6.25
With grain prices at $21 and $24 and milk at ¼ cent per quart, .	3.90	5.00
With grain prices at $21 and $24 and milk at ½ cent per quart, .	5.46	7.00

(*d*) Digestion Experiments with Sheep.

We have continued our digestion studies of the various cattle feeds during the past year. Some of the work undertaken is as yet incomplete, and experiments are still in progress. Below is presented the digestion coefficients obtained with several feed stuffs. The entire data will be presented at another time. By digestion coefficients is meant the percentage of the several groups of constituents composing feed stuffs that the animal is capable of digesting. Thus, if wheat bran contains 16 per cent. of protein, or 16 pounds in 100, and the coefficient of the protein digestibility is 78, this means that the animal can digest 78 per cent. of the 16 pounds, or 12.48 pounds.

Digestion Coefficients obtained.

KIND OF FODDER.	Number of Different Samples.	Number of Single Trials.	Dry Matter (Per Cent.).	Fiber (Per Cent.).	Fat (Per Cent.).	Protein (Per Cent.).	Extract Matter (Per Cent.).
Rice meal,	1	2	74	(?)	91	62	92
Pope gluten feed,	1	2	87	77	81	86	90
Pope gluten meal,	1	2	93	(?)	98	84	88
Millet and soy-bean ensilage,	1	4	59	69	72	57	59
Corn and soy-bean ensilage,	1	3	69	65	82	65	75
Hay (mostly timothy),	1	2	55	57	57	54	55

COMPILATION OF ANALYSES OF FODDER ARTICLES AND DAIRY PRODUCTS,

MADE AT

AMHERST, MASS.

1868-1897.

PREPARED BY E. B. HOLLAND.

A. FODDER ARTICLES.
B. FERTILIZING INGREDIENTS IN FODDERS.
C. DAIRY PRODUCTS.

A. Composition and Digestibility of Cattle Feeds.

[Figures equal percentages or pounds in 100.]

NAME.	Analyses.	COMPOSITION.										DIGESTIBILITY.							
		FRESH OR AIR-DRY SUBSTANCE.						WATER-FREE SUBSTANCE.				FRESH OR AIR-DRY SUBSTANCE.				WATER-FREE SUBSTANCE.			
		Water.	Ash.	Cellulose.	Fat.	Protein.	Nitrogen-free Extract	Cellulose.	Fat.	Protein.	Nitrogen-free Extract.	Cellulose.	Fat.	Protein.	Nitrogen-free Extract.	Cellulose.	Fat.	Protein.	Nitrogen-free Extract.
I. Green Fodders.																			
Corn fodder,	33	75.	1.2	5.2	0.5	2.0	16.1	20.8	2.0	8.0	64.4	2.7	0.4	1.1	12.1	10.6	1.6	4.3	48.3
Sorghum,	6	83.	1.2	4.6	0.3	1.5	9.4	27.0	1.8	8.8	55.3	2.7	0.2	0.7	7.0	15.9	1.3	4.0	41.0
Common millet,	9	65.	1.7	11.0	1.0	2.6	18.7	31.4	2.9	7.4	53.4	-	-	-	-	-	-	-	-
Japanese millet (*Panicum italicum*),	12	75.	1.5	7.8	0.5	2.1	13.1	31.2	2.0	8.2	52.5	-	-	-	-	-	-	-	-
Panicum miliaceum,	1	69.	1.7	8.2	1.2	1.8	18.1	26.5	3.8	5.8	58.4	-	-	-	-	-	-	-	-
Barn-yard millet (*Panicum crus-galli*),	2	75.	1.9	7.0	0.6	2.4	13.1	27.9	2.5	9.7	52.2	-	-	-	-	-	-	-	-
Summer rape,	1	86.	2.6	2.5	0.5	2.0	6.4	17.8	3.6	14.3	45.7	-	-	-	-	-	-	-	-
Winter rape,	1	86.	3.1	1.7	0.5	2.1	6.6	12.1	3.6	15.0	47.1	-	-	-	-	-	-	-	-
Dwarf Essex rape,	1	86.	2.2	2.7	0.6	1.8	6.7	19.3	4.3	12.9	47.8	-	-	-	-	-	-	-	-
Green oats,	6	74.	2.1	7.8	0.8	3.6	11.7	30.0	3.1	13.8	45.0	4.4	0.5	2.5	8.5	16.8	1.9	9.7	32.9
Green barley,	1	79.	1.8	7.9	0.6	2.7	8.0	37.6	2.8	12.9	38.1	4.4	0.4	1.9	5.8	21.1	1.7	9.0	27.8
Green rye,	2	72.	1.6	8.9	0.6	2.1	14.8	31.8	2.1	7.5	52.9	5.0	0.4	1.5	10.8	17.8	1.3	5.3	38.6
Timothy,	2	65.	1.7	11.3	0.7	3.2	18.1	32.3	2.0	9.1	51.7	5.9	0.4	1.5	11.4	16.8	1.2	4.4	32.6

Hungarian grass,	2	74.	2.1	7.0	0.5	2.6	13.8	26.9	1.9	10.0	53.1	4.8	0.3	1.6	9.1	18.3	1.0	6.2	35.0
Vetch and oats (1 to 1),	1	82.	1.7	5.4	0.5	3.0	7.4	30.0	2.8	16.7	41.1	-	-	-	-	-	-	-	-
Vetch and oats (1 to 4),	1	79.	1.9	6.3	0.8	2.8	9.2	30.0	3.8	13.3	43.8	-	-	-	-	-	-	-	-
Peas and oats,	2	84.	1.3	4.7	0.5	2.4	7.1	29.4	3.1	15.0	44.4	2.8	0.2	1.8	4.3	17.6	1.4	11.6	27.1
Barley and peas,	1	84.	1.3	5.4	0.5	2.2	6.6	33.8	3.1	13.8	41.2	3.2	0.2	1.7	4.0	20.3	1.4	10.6	29.1
Horse bean,	1	85.	0.9	4.3	0.4	2.5	6.9	28.6	2.7	16.7	46.0	-	-	-	-	-	-	-	-
Flat pea,	2	79.	1.9	5.2	0.9	6.1	6.9	24.8	4.3	29.0	32.9	-	-	-	-	-	-	-	-
Cow pea,	3	82.	1.7	3.9	0.7	3.1	8.6	21.7	3.9	17.2	47.8	-	-	-	-	-	-	-	-
Soy bean,	14	76.	2.5	6.5	1.1	4.2	9.7	27.1	4.6	17.5	40.4	3.7	0.3	3.0	6.7	16.5	1.3	12.4	27.9
Soy bean (early white),	4	70.	3.9	6.7	0.8	5.0	13.6	22.3	2.7	16.7	45.3	-	-	-	-	-	-	-	-
Soy bean (medium green),	1	70.	3.9	7.1	1.2	5.8	12.0	23.7	4.0	19.3	40.0	-	-	-	-	-	-	-	-
Soy bean (medium black)	2	75.	3.1	5.9	1.3	4.7	10.0	23.4	5.2	18.9	39.9	-	-	-	-	-	-	-	-
Soy bean (late),	4	74.	3.5	5.5	0.7	5.9	10.4	21.1	2.7	22.7	40.0	-	-	-	-	-	-	-	-
Bokhara or sweet clover,	3	79.	2.1	6.3	0.6	4.2	7.8	30.0	2.9	20.0	37.1	-	-	-	-	-	-	-	-
Serradella,	3	82.	1.9	5.3	0.4	2.6	7.8	29.5	2.2	14.4	43.3	-	-	-	-	-	-	-	-
Common vetch,	2	82.	1.5	5.5	0.4	2.7	7.9	30.6	2.2	15.0	43.9	-	-	-	-	-	-	-	-
Hairy vetch,	1	82.	1.5	5.7	0.2	3.6	7.0	31.6	1.1	20.0	38.9	-	-	-	-	-	-	-	-
Kidney vetch,	1	81.	2.6	2.9	0.7	3.5	9.3	15.3	3.7	18.4	48.9	-	-	-	-	-	-	-	-
Prickly comfrey,	1	87.	2.8	1.5	0.3	2.3	6.1	11.5	2.4	17.7	46.9	-	-	-	-	-	-	-	-
Spurry,	1	72.	2.6	7.0	0.1	2.9	15.4	25.0	0.4	10.3	55.0	-	-	-	-	-	-	-	-
Scotch tares,	1	82.	2.2	5.1	0.3	3.5	6.9	28.3	1.7	19.5	38.3	-	-	-	-	-	-	-	-

A. *Composition and Digestibility of Cattle Feeds* — Continued.

NAME.	Analyses.	COMPOSITION.										DIGESTIBILITY.							
		FRESH OR AIR-DRY SUBSTANCE.						WATER-FREE SUBSTANCE.				FRESH OR AIR DRY SUBSTANCE.				WATER-FREE SUBSTANCE.			
		Water.	Ash.	Cellulose.	Fat.	Protein.	Nitrogen-free Extract.	Cellulose.	Fat.	Protein.	Nitrogen-free Extract.	Cellulose.	Fat.	Protein.	Nitrogen-free Extract.	Cellulose.	Fat.	Protein.	Nitrogen-free Extract.
II. Ensilages.																			
Corn ensilage,	39	78.	1.2	6.0	0.8	1.9	12.1	27.3	3.6	8.6	55.0	4.1	0.6	1.0	8.0	18.6	2.8	4.6	37.9
Corn and soy-bean ensilage,	4	76.	2.4	7.2	0.8	2.5	11.1	30.0	3.3	10.4	46.3	4.7	0.7	1.6	8.3	19.5	2.7	6.8	34.7
Millet ensilage,	3	74.	2.4	7.5	0.8	1.7	13.6	28.8	3.1	6.5	52.3	-	-	-	-	-	-	-	-
Millet and soy-bean ensilage,	9	79.	2.8	7.2	1.0	2.8	7.2	34.3	4.8	13.3	34.3	-	-	-	-	-	-	-	-
Apple-pomace ensilage,	1	85.	0.6	3.3	1.1	1.2	8.8	22.0	7.3	8.0	58.7	-	-	-	-	-	-	-	-
III. (a) Hay and Dry Coarse Fodders.																			
Corn fodder,	4	20.	4.1	23.4	1.4	6.2	44.9	29.2	1.7	7.7	56.3	15.2	1.0	3.7	33.2	19.0	1.3	4.5	41.7
Corn stover,	30	20.	4.7	28.3	1.1	5.9	40.0	35.4	1.4	7.3	50.0	19.0	0.6	3.1	25.6	23.7	0.7	3.8	32.0
English hay (mixed grasses),	66	14.	5.3	26.9	2.4	8.1	43.3	31.3	2.8	9.4	50.3	16.1	1.2	4.8	25.5	18.8	1.4	5.5	29.7
Fermented hay,	1	14.	6.3	25.4	2.2	8.4	43.7	29.5	2.6	9.8	50.8	-	-	-	-	-	-	-	-
Canada hay,	4	14.	4.6	28.1	2.1	6.1	45.1	32.7	2.4	7.1	52.4	14.6	1.3	2.9	28.4	17.0	1.4	3.4	33.0
Rowen,	15	17.	5.9	22.2	3.0	10.5	41.4	26.7	3.6	12.7	49.9	14.7	1.4	7.2	26.9	17.6	1.7	8.8	32.4

Timothy,	6	14.	4.2	28.3	1.9	8.5	43.1	32.9	2.2	9.9	50.1	14.7	1.1	4.1	27.2	17.1	1.3	4.8	31.6
Red-top,	4	14.	4.3	28.3	1.4	6.8	45.2	32.9	1.6	7.9	52.6	17.3	0.7	4.1	24.4	20.1	0.8	4.8	32.6
Kentucky blue-grass,	2	14.	7.2	29.7	1.8	7.5	39.8	34.5	2.1	8.7	46.3	-	-	-	-	-	-	-	-
Orchard grass,	4	14.	6.1	30.0	2.5	8.1	39.3	34.9	2.9	9.4	45.7	19.2	1.4	4.9	21.4	22.3	1.6	5.6	25.6
Meadow fescue,	5	14.	7.9	31.7	1.0	5.8	39.0	36.9	1.9	6.7	45.3	-	-	-	-	-	-	-	-
Perennial rye-grass,	4	14.	7.9	25.4	2.1	10.1	40.5	29.5	2.4	11.8	47.1	-	-	-	-	-	-	-	-
Italian rye-grass,	4	14.	6.5	28.6	1.6	7.1	42.2	33.2	1.9	8.4	49.0	-	-	-	-	-	-	-	-
Hungarian grass,	1	14.	4.9	27.5	1.9	8.2	43.5	31.9	2.3	9.5	50.6	18.7	1.2	4.9	29.1	21.7	1.5	5.7	33.9
Barn-yard grass,	1	14.	8.6	29.0	1.7	13.1	33.6	33.7	2.0	15.2	39.1	-	-	-	-	-	-	-	-
Black grass (salt) (*Juncus Gerardi*),	2	16.	7.7	24.4	2.4	6.8	42.7	29.0	2.9	8.1	50.8	14.6	1.0	4.3	23.9	17.4	1.2	5.1	28.4
High-grown salt hay (largely *spartina juncea*).	1	16.	7.0	22.2	2.1	6.3	46.4	26.4	2.5	7.5	55.3	11.1	1.0	4.0	24.6	13.2	1.2	4.7	29.3
Branch grass (salt) (largely *spartina juncea*),	1	16.	8.8	22.3	1.8	7.0	44.1	26.6	2.2	8.3	52.4	11.6	0.6	4.3	23.8	13.8	0.7	5.1	28.3
Low meadow fox grass (salt) (*spartina juncea*).	1	16.	5.4	22.3	2.2	6.0	48.1	26.5	2.6	7.2	57.3	11.4	0.5	3.0	25.0	13.5	0.6	4.1	29.8
Salt hay (variety unknown),	2	16.	4.3	24.0	2.5	3.4	49.8	28.6	3.0	4.0	59.3	-	-	-	-	-	-	-	-
Swamp or swale hay,	2	14.	5.8	26.7	1.9	7.1	44.5	31.0	2.2	8.3	51.8	8.8	0.8	2.4	20.5	10.2	1.0	2.8	23.8
Vetch and oats (1 to 1),	1	14.	8.1	25.8	2.4	14.4	35.3	30.0	2.8	16.7	41.1	-	-	-	-	-	-	-	-
Vetch and oats (1 to 4),	1	14.	7.8	25.8	3.3	11.4	37.7	30.0	3.8	13.3	43.8	17.0	2.6	0.8	20.4	19.8	3.0	8.0	23.7
Vetch and barley,	2	14.	5.3	27.9	2.0	11.9	38.9	32.4	2.3	13.8	45.2	18.4	1.6	7.1	21.0	21.4	1.8	8.3	24.4
Oats in bloom,	1	15.	5.6	30.6	2.4	5.5	40.9	36.0	2.8	6.5	48.1	17.1	1.5	3.9	29.9	20.2	1.7	4.6	35.1
Oats in milk,	1	15.	5.2	29.2	2.3	9.3	39.0	34.4	2.7	10.9	45.9	16.4	1.4	6.5	28.5	19.3	1.7	7.6	33.5
Oats, ripe,	1	15.	5.3	30.9	2.2	5.2	41.4	36.4	2.6	6.1	48.7	-	-	-	-	-	-	-	-
Winter rye in bloom,	1	15.	5.4	28.1	2.2	9.1	40.2	33.0	2.6	10.7	47.3	-	-	-	-	-	-	-	-

A. Composition and Digestibility of Cattle Feeds — Continued.

NAME.	Analyses.	COMPOSITION.										DIGESTIBILITY.							
		FRESH OR AIR-DRY SUBSTANCE.						WATER-FREE SUBSTANCE.				FRESH OR AIR-DRY SUBSTANCE.				WATER-FREE SUBSTANCE.			
		Water.	Ash.	Cellulose.	Fat.	Protein.	Nitrogen-free Extract.	Cellulose.	Fat.	Protein.	Nitrogen-free Extract.	Cellulose.	Fat.	Protein.	Nitrogen-free Extract.	Cellulose.	Fat.	Protein.	Nitrogen-free Extract.
III. (a) Hay and Dry Coarse Fodders — Con.																			
Barley in milk,	1	15.	4.2	24.7	2.4	8.8	44.9	29.0	2.8	10.4	52.8	13.8	1.5	6.2	32.8	16.2	1.7	7.3	38.5
Common millet,	6	15.	4.3	28.3	1.8	6.6	44.0	33.3	2.1	7.8	51.8	-	-	-	-	-	-	-	-
Japanese millet,	3	15.	4.7	30.1	1.8	5.1	43.3	35.4	2.1	6.0	50.9	-	-	-	-	-	-	-	-
III. (b) Legumes.																			
Mammoth red clover,	5	15.	8.1	24.4	1.8	13.1	37.6	28.7	2.1	15.4	44.2	-	-	-	-	-	-	-	-
Medium red clover,	4	15.	7.3	26.0	2.4	11.8	37.5	30.6	2.7	13.9	44.1	12.0	1.3	6.5	24.0	14.1	1.4	7.6	28.2
Alsike clover,	8	15.	9.8	23.1	2.1	14.0	36.0	27.2	2.5	16.5	42.4	12.2	1.1	9.2	25.6	14.4	1.3	10.9	30.1
Lucerne (alfalfa),	6	15.	6.8	26.1	1.6	11.6	38.9	30.7	1.9	13.6	45.8	11.2	0.8	8.0	28.0	13.2	0.9	9.4	33.0
Sand lucerne,	1	15.	8.3	18.0	2.2	13.9	42.6	21.2	2.6	16.4	50.0	-	-	-	-	-	-	-	-
English gray pea,	1	15.	8.2	25.7	2.7	17.5	30.9	30.2	3.2	20.6	36.4	-	-	-	-	-	-	-	-
Canada beauty pea,	1	15.	6.7	24.7	2.3	13.7	37.6	29.0	2.7	16.1	44.3	-	-	-	-	-	-	-	-
Sainfoln,	1	15.	7.3	20.4	3.0	14.8	39.5	24.0	3.5	17.4	46.5	-	-	-	-	-	-	-	-

III. (c) Straw.																			
Wheat straw,	1	15.	4.1	30.5	1.4	6.2	42.8	35.9	1.6	7.3	50.4	15.9	0.4	0.7	16.3	18.7	0.5	0.8	19.2
Barley straw,	2	15.	4.8	32.2	2.5	6.5	39.0	37.9	2.9	7.7	45.9	18.0	1.1	1.3	21.1	21.2	1.2	1.5	24.8
Millet straw,	1	15.	5.8	35.5	1.2	4.2	38.3	41.8	1.4	4.9	45.1	–	–	–	–	–	–	–	–
Straw (*P. crus-galli*),	1	15.	4.6	30.4	2.1	5.2	42.7	35.8	2.5	6.1	50.2	–	–	–	–	–	–	–	–
Straw (*P. miliaceum*),	1	15.	5.2	35.9	2.5	3.3	38.1	42.2	3.0	3.9	44.8	–	–	–	–	–	–	–	–
Straw (*P. Italicum*),	1	15.	5.3	35.2	1.4	3.6	39.5	41.4	1.7	4.2	46.5	–	–	–	–	–	–	–	–
Soy-bean straw,	3	15.	6.1	36.1	1.8	4.7	36.3	42.5	2.1	5.5	42.7	13.7	0.1	2.4	24.0	16.2	1.3	2.8	28.2
Horse-bean straw,	1	15.	8.1	35.2	1.3	8.3	32.1	41.4	1.5	9.8	37.8	13.7	0.7	4.1	20.5	16.1	0.8	4.8	24.2
III. (d) Miscellaneous.																			
Teosinte,	1	15.	6.0	24.5	1.1	8.2	45.2	28.8	1.3	9.6	53.2	–	–	–	–	–	–	–	–
Sulla,	2	15.	7.9	17.6	2.3	14.5	42.7	20.7	2.7	17.1	50.2	–	–	–	–	–	–	–	–
Hairy lotus,	2	15.	7.0	16.8	2.5	12.6	46.1	19.8	3.0	14.8	54.2	–	–	–	–	–	–	–	–
White daisy,	1	15.	6.0	30.7	2.0	6.6	39.7	36.1	2.4	7.8	46.7	14.1	1.2	3.8	26.6	16.6	1.5	4.5	31.3
Carrot tops,	1	15.	11.8	11.6	1.7	18.0	41.9	13.6	2.0	21.2	49.3	–	–	–	–	–	–	–	–
IV. Roots, Tubers, Fruits, etc.																			
Beets, red,	7	88.	1.1	0.7	0.1	1.5	8.6	5.8	0.8	12.5	71.7	0.5	0.1	1.4	8.6	4.3	0.4	11.4	71.7
Beets, sugar,	12	86.	0.8	0.9	0.1	1.5	10.7	6.4	0.7	10.7	76.5	0.7	0.1	1.4	10.7	4.8	0.4	9.7	76.5
Beets, yellow fodder,	4	89.	1.0	1.0	0.2	1.3	7.5	9.1	1.8	11.8	68.2	0.8	0.1	1.2	7.5	6.8	0.9	10.7	68.2
Mangolds,	5	88.	1.2	0.8	0.1	1.4	8.5	6.7	0.8	11.7	70.8	0.6	0.1	1.3	8.5	5.0	0.4	10.6	70.8
Turnips,	5	90.	0.9	1.2	0.2	1.1	6.6	12.0	2.0	11.0	66.0	0.9	0.2	1.0	6.4	9.0	2.0	9.9	64.0

A. Composition and Digestibility of Cattle Feeds — Continued.

NAME.	Analyses.	COMPOSITION.										DIGESTIBILITY.							
		FRESH OR AIR-DRY SUBSTANCE.						WATER-FREE SUBSTANCE.				FRESH OR AIR-DRY SUBSTANCE.				WATER-FREE SUBSTANCE.			
		Water.	Ash.	Cellulose.	Fat.	Protein.	Nitrogen-free Extract.	Cellulose.	Fat.	Protein.	Nitrogen-free Extract.	Cellulose.	Fat.	Protein.	Nitrogen-free Extract.	Cellulose.	Fat.	Protein.	Nitrogen-free Extract.
IV. Roots, Tubers, Fruits, etc. — Con.																			
Ruta-bagas,	3	89.	1.1	1.3	0.2	1.2	7.2	11.8	1.8	10.9	65.5	1.0	0.2	1.0	6.8	8.8	1.5	8.7	62.2
Carrots,	5	89.	0.9	1.1	0.2	1.0	7.8	10.0	1.8	9.1	70.9	-	-	-	-	-	-	-	-
Parsnips,	1	80.	1.5	1.5	0.7	1.3	15.0	7.5	3.5	6.5	75.0	-	-	-	-	-	-	-	-
Potatoes,	14	81.	1.0	0.5	0.1	1.9	15.5	2.6	0.5	10.0	81.6	-	-	0.8	14.1	-	-	4.4	74.2
Artichokes,	1	78.	1.1	0.9	0.2	2.9	16.9	4.1	0.9	13.1	76.9	-	-	-	-	-	-	-	-
Apples,	2	78.	0.7	1.5	0.5	1.0	18.3	6.8	2.3	4.5	83.2	-	-	-	-	-	-	-	-
Apple pomace,	3	83.	0.4	2.9	0.8	1.2	11.7	17.0	4.7	7.1	68.8	-	-	-	-	-	-	-	-
Sugar-beet pulp,	1	90.	0.1	2.5	0.1	1.4	5.9	25.0	1.0	14.0	59.0	-	-	-	-	-	-	-	-
Cranberries,	1	89.	0.2	1.2	0.6	0.5	8.5	10.9	5.5	4.5	77.3	-	-	-	-	-	-	-	-
Japanese radish (*merinia*),	1	93.	0.7	0.7	0.1	0.5	5.0	10.0	1.4	7.1	71.5	-	-	-	-	-	-	-	-
Japanese radish (*niyas-hige*),	1	93.	0.7	0.7	0.1	0.5	5.0	10.0	1.4	7.1	71.5	-	-	-	-	-	-	-	-
V. Grains, Seeds, etc.																			
Corn kernels,	29	10.6	1.5	1.9	4.8	10.9	70.3	2.1	5.3	12.2	78.8	-	-	-	-	-	-	-	-
Sweet corn kernels,	1	12.0	1.4	2.1	8.4	11.1	65.0	2.4	9.5	12.6	73.9	-	-	-	-	-	-	-	-

Wheat kernels,	3	10.6	1.8	2.2	1.7	12.4	71.3	2.5	1.9	13.9	79.7	-	-	-	-	-	-	-	-
Oat kernels,	3	10.8	3.0	8.5	5.5	13.6	58.6	9.5	6.2	15.3	65.6	1.8	3.9	11.7	43.4	2.0	4.4	13.6	48.5
Broom-corn seed,	1	14.1	2.2	7.1	3.5	9.6	63.5	8.3	4.0	11.2	73.9	-	-	-	-	-	-	-	-
Soy beans,	4	13.0	5.1	5.0	17.2	31.2	28.5	5.7	19.8	35.8	32.8	2.5	14.6	28.1	20.5	2.8	16.8	32.2	23.6
Red adzinki beans,	2	15.9	3.5	3.9	0.7	20.6	55.4	4.7	0.8	24.4	65.9	-	-	-	-	-	-	-	-
Saddle beans,	1	12.4	5.4	4.2	14.5	13.2	50.3	4.8	16.5	15.1	57.4	-	-	-	-	-	-	-	-
Horse beans,	1	10.3	3.9	7.3	0.9	26.9	50.7	8.1	1.0	30.0	56.5	5.3	0.8	23.7	47.2	5.8	0.9	26.4	52.5
Millet seed,	3	13.3	2.6	7.7	3.7	11.4	61.3	8.9	4.3	13.2	70.6	-	-	-	-	-	-	-	-
Barn-yard millet seed (*P. crus-galli*),	1	10.3	3.1	7.7	5.7	12.3	60.9	8.6	6.3	13.7	67.7	-	-	-	-	-	-	-	-
Chestnuts,	1	44.9	1.5	1.4	8.0	7.3	36.9	2.5	14.5	13.3	67.0	-	-	-	-	-	-	-	-
VI. Flour and Meal.																			
Corn meal,	40	13.6	1.4	1.9	3.4	9.6	70.1	2.2	3.9	11.1	81.1	-	3.1	5.8	65.2	-	3.6	6.7	75.4
Corn and cob meal,	37	10.5	1.4	6.7	3.7	9.0	68.7	7.5	4.1	10.0	76.8	3.0	3.0	0.5	60.5	3.4	3.4	5.2	67.5
Cooked feed (oats and corn),	1	5.5	3.8	8.2	5.0	14.0	63.5	8.6	5.0	14.8	67.6	-	-	-	-	-	-	-	-
Ground wheat,	1	11.5	2.0	2.9	2.0	12.1	69.5	3.3	2.2	13.7	78.6	-	-	-	-	-	-	-	-
Ground oats,	2	9.3	3.5	8.5	3.6	11.4	63.7	9.4	4.0	12.6	70.2	1.7	3.0	8.9	48.4	1.9	3.3	9.9	53.4
Ground barley,	5	13.1	2.4	5.7	1.9	11.3	65.6	6.5	2.2	13.0	75.6	2.9	1.7	7.9	64.0	3.3	2.0	9.1	69.6
Broom-corn meal,	1	13.5	2.1	6.9	3.5	9.7	64.3	8.0	4.1	11.2	74.3	-	-	-	-	-	-	-	-
Pea meal,	1	8.8	2.6	17.7	1.6	19.2	50.1	19.4	1.8	21.0	54.9	4.6	0.9	15.9	47.1	5.0	1.0	1.7	51.6
Peanut meal,	1	8.0	4.0	3.5	10.8	49.0	24.7	3.8	11.8	53.3	26.8	0.8	9.6	44.6	22.7	0.9	10.5	48.5	24.7
"Red dog" flour,	1	9.7	1.9	1.4	4.4	22.6	60.0	1.6	4.9	25.0	66.4	-	-	-	-	-	-	-	-

A. Composition and Digestibility of Cattle Feeds — Continued.

NAME.	Analyses.	COMPOSITION.										DIGESTIBILITY.							
		FRESH OR AIR-DRY SUBSTANCE.						WATER-FREE SUBSTANCE.				FRESH OR AIR-DRY SUBSTANCE.				WATER-FREE SUBSTANCE.			
		Water.	Ash.	Cellulose.	Fat.	Protein.	Nitrogen-free Extract.	Cellulose.	Fat.	Protein.	Nitrogen-free Extract.	Cellulose.	Fat.	Protein.	Nitrogen-free Extract.	Cellulose.	Fat.	Protein.	Nitrogen-free Extract.
VI. Flour and Meal — Concluded.																			
Bean meal,	1	12.0	1.4	2.1	8.5	11.0	65.0	2.4	9.7	12.5	73.8	1.5	7.3	9.7	60.5	1.7	8.3	11.0	68.6
Soy-bean meal,	1	9.2	5.0	3.9	16.3	34.8	30.8	4.3	18.0	38.3	33.9	2.0	13.9	31.3	22.2	2.9	15.3	54.5	24.4
VII. (a) By-products and Refuse.																			
Cotton-seed meal,	36	8.0	6.9	6.7	10.7	42.0	25.7	7.3	11.6	45.6	27.9	2.1	10.0	37.0	16.4	2.3	10.8	40.1	17.9
Cotton-seed meal (meats and hull),	1	7.8	3.6	19.8	6.7	26.4	35.7	21.4	7.2	28.7	38.8	-	-	-	-	-	-	-	-
Linseed meal, old process,*	9	9.7	6.0	7.6	6.6	33.5	36.6	8.4	7.3	37.1	40.5	4.3	5.9	29.8	28.5	4.8	6.5	33.0	31.6
Cleveland linseed meal,	8	8.3	5.9	8.5	2.9	36.1	38.3	9.3	3.2	39.3	41.8	6.3	2.7	30.7	32.2	6.9	3.0	33.4	35.1
Cleveland flax meal,	1	9.9	5.3	7.6	2.5	40.2	34.5	8.4	2.8	44.6	38.3	-	-	-	-	-	-	-	-
Cocoanut meal,	1	9.3	5.2	17.1	11.7	20.5	36.2	18.8	12.9	22.6	40.0	-	-	-	-	-	-	-	-
VII. (b) Gluten Products.																			
Chicago gluten meal, old process,	3	9.2	0.8	1.1	6.2	30.4	52.3	1.2	6.8	33.5	57.6	-	5.8	27.1	48.6	-	6.3	29.8	53.6
Chicago gluten meal, new process,	6	9.2	1.3	2.5	6.1	37.8	43.1	2.8	6.7	41.5	47.4	-	5.7	33.6	40.1	-	6.2	36.9	44.1

King gluten meal,	3	7.7	1.9	1.4	19.0	35.4	34.6	1.5	20.6	38.4	36.4	-	17.9	32.2	27.3	-	19.4	34.9	28.8
Pope gluten meal (cream),	2	8.0	0.6	1.7	10.2	36.2	43.3	1.8	11.1	39.3	47.1	-	10.0	30.4	38.1	-	10.9	33.0	41.4
Iowa gluten meal (golden),	1	4.8	1.2	6.9	12.9	25.7	48.5	7.2	13.5	27.0	51.0	5.4	10.2	21.3	43.7	5.6	10.7	22.4	45.9
Hammond gluten meal,	1	8.2	1.1	1.5	9.7	29.9	49.6	1.6	10.6	32.6	54.0	-	9.0	26.6	46.1	-	9.9	29.0	50.2
Gluten meal (varieties uncertain),	38	9.0	0.9	3.3	8.3	27.3	51.2	3.6	9.1	30.0	56.3	-	7.6	24.3	45.1	-	8.4	26.7	49.5
Buffalo gluten feed,	18	8.2	0.9	6.8	11.5	23.2	49.4	7.4	12.5	25.2	53.6	5.3	9.1	19.3	44.5	5.8	9.9	20.9	48.2
Buffalo gluten feed,†	1	10.5	2.6	6.7	4.4	27.1	48.7	7.5	4.9	30.3	54.4	5.2	3.3	22.5	43.8	5.8	3.9	25.1	49.0
Peoria gluten feed,	8	6.9	0.6	7.4	11.5	21.4	52.2	8.0	12.4	23.0	56.1	5.8	9.1	17.8	47.0	6.2	9.8	19.1	50.5
Pope gluten feed,	2	8.0	1.3	6.3	8.4	25.3	50.7	6.9	9.1	27.5	55.1	4.9	6.6	21.0	45.6	5.4	7.2	22.8	49.6
Diamond gluten feed,	1	8.4	1.1	7.3	10.2	22.0	51.0	8.0	11.1	24.0	55.7	5.7	8.1	18.3	45.9	6.2	8.8	19.9	50.1
Chicago maize feed,	5	8.2	0.6	7.5	7.1	24.9	51.7	8.2	7.7	27.1	56.3	5.4	6.4	20.9	43.9	5.9	6.9	22.8	47.9
Starch feed (Pope),	1	5.5	0.8	14.5	10.7	10.7	57.8	15.2	11.3	11.3	61.3	-	-	-	-	-	-	-	-
Glucose feed (Richardson),	1	6.3	1.0	11.0	11.0	21.6	49.1	11.7	11.7	23.1	52.4	-	-	-	-	-	-	-	-
Corn germ feed,	1	7.5	0.8	13.0	11.3	10.0	57.4	14.1	12.2	10.8	62.0	-	-	-	-	-	-	-	-
Atlas gluten feed,	9	7.5	1.7	11.0	12.6	31.5	35.7	11.9	13.6	34.1	38.6	11.0	11.5	23.0	30.0	11.9	12.4	24.9	32.4
Corn screenings,	1	11.1	2.1	2.9	4.0	7.4	72.5	3.3	4.5	8.3	81.5	-	-	-	-	-	-	-	-
Dried brewer's grain,	5	9.0	3.8	10.6	4.9	22.8	48.9	11.7	5.4	25.1	53.7	5.6	4.5	18.0	28.9	6.2	4.9	19.8	31.7
Wet brewer's grain,	1	77.0	0.7	3.8	2.0	6.7	9.8	16.7	8.5	29.0	42.5	-	-	-	-	-	-	-	-
Malt sprouts,	2	12.0	5.2	12.8	2.6	24.3	43.1	14.6	3.0	27.6	49.0	4.4	2.6	19.4	29.7	5.0	3.0	22.1	33.8

---

* National Linseed Oil Company.

† Improved process.

A. *Composition and Digestibility of Cattle Feeds* — Continued.

NAME.	Analyses.	COMPOSITION.										DIGESTIBILITY.							
		FRESH OR AIR-DRY SUBSTANCE.						WATER-FREE SUBSTANCE				FRESH OR AIR-DRY SUBSTANCE				WATER-FREE SUBSTANCE.			
		Water.	Ash.	Cellulose.	Fat.	Protein.	Nitrogen-free Extract.	Cellulose.	Fat.	Protein.	Nitrogen-free Extract.	Cellulose.	Fat.	Protein.	Nitrogen-free Extract.	Cellulose.	Fat.	Protein.	Nitrogen-free Extract.
VII. (c) Brans and Middlings.																			
Cotton-hull bran,	1	11.	1.9	35.0	1.1	2.3	48.7	39.3	1.2	2.6	54.7	-	-	-	-	-	-	-	-
Spring wheat bran,	4	11.	5.7	10.4	5.0	15.9	52.0	11.7	5.6	17.9	58.4	2.5	3.8	12.7	36.4	2.8	4.2	14.3	40.9
Winter wheat bran,	3	11.	6.2	8.5	2.9	15.1	56.3	9.6	3.2	17.0	63.3	2.3	1.9	11.6	36.6	2.6	2.0	13.1	41.1
Wheat bran (average),	53	11.	6.7	9.6	4.5	16.1	52.1	10.8	5.0	18.1	58.5	2.1	3.2	12.6	35.4	2.4	3.6	14.1	39.8
Heavy bran (bran and flour),	2	11.	4.1	7.2	4.5	16.8	56.4	8.1	5.1	18.4	63.4	-	-	-	-	-	-	-	-
Boston mixed feed,	1	11.	4.8	6.3	4.6	19.2	54.1	7.1	5.2	21.6	60.8	-	-	-	-	-	-	-	-
"Imperial mill" mixed feed,	1	11.	3.1	5.1	4.5	15.0	61.3	5.7	5.0	16.9	68.8	-	-	-	-	-	-	-	-
Quincy mixed feed,	1	11.	4.8	6.9	5.1	16.5	55.7	7.8	5.7	18.5	62.6	-	-	-	-	-	-	-	-
Rye bran,	2	11.	4.1	3.5	2.3	15.6	63.5	4.0	2.6	17.8	71.3	-	-	-	-	-	-	-	-
Pea bran,	1	11.	2.9	41.1	1.1	9.2	34.7	46.2	1.2	10.3	39.0	-	-	-	-	-	-	-	-
Louisiana rice bran,	1	11.	9.4	13.3	8.6	8.7	49.0	14.9	9.7	9.8	55.0	-	-	-	-	-	-	-	-
Wheat middlings,	11	11.	5.1	6.6	4.8	15.8	56.7	7.4	5.4	17.8	63.7	23.8	4.1	13.4	49.9	2.7	4.6	15.1	56.1
Rye middlings,	1	11.	3.6	3.3	5.0	11.7	65.4	3.7	5.6	13.2	73.5	-	-	-	-	-	-	-	-

Oat middlings,	1	11.	4.2	17.4	3.3	10.8	53.3	19.5	3.7	12.1	59.9	-	-	-	-	-	-	-	-
Buckwheat middlings,	1	11.	4.8	4.6	6.7	22.7	50.2	5.2	7.5	25.5	56.4	-	-	-	-	-	-	-	-
VII. (d) Miscellaneous.																			
Cotton hulls,	4	11.	2.6	40.2	2.8	5.8	37.6	45.2	3.1	6.5	42.2	18.9	2.2	3.2	12.8	21.2	2.4	3.7	14.3
Cotton-seed feed,	2	10.	3.0	37.6	3.4	10.4	35.6	41.8	3.8	11.6	39.5	-	-	-	-	-	-	-	-
Hominy meal (previous to 1891),	4	8.	2.3	3.9	9.0	9.6	67.2	4.3	9.8	10.4	73.1	-	-	-	-	-	-	-	-
Hominy chop or meal,*	1	7.8	2.9	4.3	9.8	11.8	63.4	4.6	10.6	12.8	68.9	-	-	-	-	-	-	-	-
Cerealine,	2	10.	2.7	5.4	8.9	12.1	60.9	6.0	9.9	13.4	67.7	-	-	-	-	-	-	-	-
Rice meal,	2	10.2	8.1	5.4	13.1	12.0	51.2	6.0	14.6	13.2	57.0	-	11.9	7.4	47.1	-	13.3	8.2	52.4
Excelsior feed,	1	7.1	4.1	13.7	5.0	9.1	61.0	14.7	5.4	9.8	65.7	-	-	-	-	-	-	-	-
Oat feed,	20	7.5	5.0	15.1	4.0	11.1	57.3	16.3	4.3	12.0	61.9	-	-	-	-	-	-	-	-
Proteina,	4	8.4	2.5	10.0	6.6	21.7	50.8	10.9	7.2	23.7	55.5	-	-	-	-	-	-	-	-
Hall's dairy feed,	1	7.2	6.1	10.2	9.5	20.8	46.2	11.0	10.2	22.4	49.8	-	-	-	-	-	-	-	-
Rye feed,	2	8.9	2.7	3.3	2.6	13.8	68.7	3.6	2.9	15.1	75.4	-	-	-	-	-	-	-	-
Peanut feed,	2	10.0	2.6	56.4	5.5	8.9	16.6	62.7	6.1	9.9	18.4	6.8	5.0	6.3	8.1	7.5	5.5	7.0	9.0
Peanut husks,	1	13.0	1.2	66.0	1.7	5.0	13.1	75.9	1.9	5.7	15.1	-	-	-	-	-	-	-	-
Bakery refuse,	1	13.3	10.1	0.3	5.5	8.0	62.8	0.4	6.4	9.2	72.4	-	-	-	-	-	-	-	-
Vinegar mash,	1	94.5	0.2	0.5	0.5	0.9	3.4	8.6	8.5	16.5	63.4	-	-	-	-	-	-	-	-
Refuse from starch works,	1	57.0	0.4	3.2	4.4	9.6	25.4	7.5	10.2	22.4	59.0	-	-	-	-	-	-	-	-
Glucose refuse,	1	6.7	1.1	4.5	9.9	19.7	58.1	4.8	10.6	21.1	62.3	-	-	-	-	-	-	-	-

* Recent analysis.

A. *Composition and Digestibility of Cattle Feeds* — Concluded.

NAME.	Analyses.	COMPOSITION.										DIGESTIBILITY.							
		FRESH OR AIR-DRY SUBSTANCE.						WATER-FREE SUBSTANCE.				FRESH OR AIR-DRY SUBSTANCE.				WATER-FREE SUBSTANCE.			
		Water.	Ash.	Cellulose.	Fat.	Protein.	Nitrogen-free Extract.	Cellulose.	Fat.	Protein.	Nitrogen-free Extract.	Cellulose.	Fat.	Protein.	Nitrogen-free Extract.	Cellulose.	Fat.	Protein.	Nitrogen-free Extract.
VII. (d) Miscellaneous — Concluded.																			
Damaged wheat,	1	18.1	2.0	2.7	2.2	14.2	65.8	3.1	2.5	16.3	75.8	-	-	-	-	-	-	-	-
Cocoa dust,	1	7.1	6.3	5.5	24.1	14.4	42.6	5.9	25.9	15.5	45.9	-	-	-	-	-	-	-	-
Broom-corn waste,	1	8.7	4.5	35.9	0.9	6.1	43.9	39.3	1.0	6.8	48.0	-	-	-	-	-	-	-	-
Sugar-beet refuse,	1	28.9	5.3	5.8	0.3	8.6	51.1	8.1	0.4	12.1	71.9	-	-	-	-	-	-	-	-
Corn cobs,	6	7.6	1.3	31.4	0.5	2.7	56.5	34.0	0.6	2.9	61.1	20.4	0.3	0.5	33.9	22.1	0.3	0.5	36.7
Palmetto root,	1	11.5	3.9	18.9	0.4	3.4	61.9	21.3	0.5	3.8	70.0	-	-	-	-	-	-	-	-
Ground cloves,	2	12.2	7.4	28.1	2.0	13.2	37.1	32.0	2.3	15.0	42.3	-	-	-	-	-	-	-	-
Calf meal (Blatchford),	1	8.1	4.3	4.6	4.5	25.6	52.9	5.0	4.9	27.8	57.6	-	-	-	-	-	-	-	-
Animal meal (Bowker's),	1	5.1	28.6	-	16.2	40.0	-	-	17.1	42.2	-	-	-	-	-	-	-	-	-

B. *Fertilizing Ingredients in Fodder Articles.*

[Figures equal percentages or pounds in 100.]

NAME.	Analyses.	Water.	Nitrogen.	Potassium Oxide.	Phosphoric Acid.	Valuation per 2,000 Pounds.*
I. Green Fodders.						
Corn fodder,	14	79.	.41	.33	.15	$1 45
Sorghum,	7	83.	.23	.23	.09	86
Barn-yard millet (*Panicum crus-galli*),	1	75.	.46	.49	.11	1 69
Japanese millet (*P. Italicum*),	3	63.	.61	.41	.19	2 05
Summer rape,	1	86.	.32	.73	.09	1 60
Green oats,	3	83.	.49	.38	.13	1 67
Green rye,	2	72.	.30	.64	.12	1 47
Hungarian grass,	1	74.	.39	.54	.16	1 62
Vetch and oats,	1	86.	.24	.79	.09	1 45
Horse bean,	1	75.	.68	.35	.08	2 05
Flat pea,	1	79.	1.05	.45	.14	3 10
Cow pea,	1	82.	.32	.18	.10	1 04
Small pea,	1	82.	.48	.37	.11	1 62
Soy bean,	1	73.	.29	.53	.15	1 36
Soy bean (early white),	1	67.	.94	.91	.21	3 36
Soy bean (medium green),	1	70.	.84	.71	.20	2 91
Soy bean (medium black),	1	77.	.80	.57	.18	2 65
Soy bean (late),	1	80.	.60	.68	.14	2 25
Bokhara or sweet clover,	1	79.	.45	.42	.13	1 62
Serradella,	2	83.	.41	.42	.14	1 53
Spring vetch,	1	85.	.36	.45	.10	1 40
Kidney vetch,	1	81.	.56	.35	.09	1 78
Prickly comfrey,	1	87.	.37	.76	.12	1 76
Common buckwheat,	1	85.	.44	.54	.09	1 67
Silver-hull buckwheat,	1	85.	.29	.39	.14	1 21
Japanese buckwheat,	1	85.	.26	.53	.14	1 08
Corn ensilage,	7	80.	.42	.39	.13	1 52
Corn and soy-bean ensilage,	1	71.	.79	.44	.42	2 51
Millet ensilage,	3	74.	.26	.62	.14	1 37
Millet and soy-bean ensilage,	5	76.	.48	.50	.12	1 76
II. Hay and Dry Coarse Fodders.						
Corn fodder,	7	20.	1.53	.77	.47	4 87
Corn stover,	17	20.	.92	1.22	.26	3 66

* Using the figures for the retail cost of nitrogen, phosphoric acid and potash in fertilizers, the amounts obtained show comparative rather than actual values, because the ingredients in fertilizers are easier to handle and in a more available form than in fodders.

B. *Fertilizing Ingredients in Fodder Articles* — Continued.

NAME.	Analyses.	Water.	Nitrogen.	Potassium Oxide.	Phosphoric Acid.	Valuation per 2,000 Pounds.*
II. Hay and Dry Coarse Fodders — Con.						
English hay,	12	15.	1.27	1.50	.29	$4 81
Rowen,	13	15.	1.70	1.56	.46	6 05
Timothy,	3	15.	1.19	1.40	.33	4 55
Red top,	4	15.	1.06	.94	.33	3 78
Kentucky blue-grass,	2	15.	1.19	1.52	.39	4 73
Orchard grass,	4	15.	1.22	1.58	.38	4 85
Meadow fescue,	6	15.	.92	1.96	.37	4 50
Perennial rye-grass,	2	15.	1.15	1.45	.52	4 68
Italian rye-grass,	4	15.	1.11	1.18	.52	4 32
Salt hay,	1	15.	1.06	.65	.23	3 40
Millet,	1	15.	1.22	1.61	.46	4 95
Vetch and oats,	3	15.	1.23	1.27	.62	4 78
Mammoth red clover,	3	15.	2.14	1.16	.52	6 76
Medium red clover,	2	15.	2.01	2.11	.41	7 30
Alsike clover,	6	15.	2.26	2.10	.63	8 09
Lucerne (alfalfa),	4	15.	1.87	1.32	.48	6 04
Sainfoin,	1	15.	2.54	1.95	.73	8 69
Barley straw,	2	15.	.95	2.03	.19	4 48
Soy-bean straw,	1	15.	.69	1.04	.25	2 92
Millet straw,	1	15.	.68	1.73	.18	3 52
Teosinte,	1	15.	1.32	3.35	.16	6 66
White lupine,	1	15.	2.56	1.46	.29	7 87
Yellow lupine,	1	15.	2.28	2.51	.51	12 57
Spanish moss,	1	15.	.61	.56	.07	2 09
Sulla,	2	15.	2.31	1.96	.42	7 88
White daisy,	1	15.	.26	1.18	.41	2 17
Carrot tops,	1	15.	2.95	4.60	.57	12 19
III. Roots, Tubers, Fruits, etc.						
Beets, red,	8	88.	.24	.44	.09	1 10
Beets, sugar,	4	87.	.22	.48	.10	1 10
Beets, yellow fodder,	1	91.	.19	.46	.09	99
Mangolds,	3	88.	.15	.34	.14	83
Turnips,	4	90.	.17	.38	.12	90
Ruta-bagas,	3	89.	.19	.49	.12	1 03

* See note on page 251.

B. Fertilizing Ingredients in Fodder Articles — Continued.

NAME.	Analyses.	Water.	Nitrogen.	Potassium Oxide.	Phosphoric Acid.	Valuation per 2,000 Pounds.*
III. Roots, Tubers, Fruits, etc. — Con.						
Carrots,	3	89.	.16	.46	.09	$0 93
Parsnips,	1	80.	.22	.62	.19	1 32
Potatoes,	4	80.	.29	.51	.08	1 29
Artichokes,	1	78.	.46	.48	.17	1 74
Apples,	2	80.	.13	.19	.01	51
Apple pomace,	2	81.	.23	.13	.02	70
Cranberries,	1	89.	.08	.10	.03	32
Japanese radish (*merinia*),	1	93.	.08	.28	.05	52
Japanese radish (*niyas hige*),	1	93.	.08	.34	.05	58
IV. Grains, Seeds, etc.						
Corn kernels,	13	10.9	1.82	.40	.70	5 04
Oat kernels,	1	9.0	2.10	–	–	–
Soy bean,	2	18.3	5.30	1.99	1.87	16 39
Red adzinki beans,	1	14.8	3.24	1.54	.94	10 16
White adzinki beans,	1	16.9	3.33	1.48	.97	10 35
Saddle beans,	1	12.3	2.12	2.13	1.52	8 59
Common millet,	2	11.5	2.01	.45	.96	6 02
Japanese millet,	1	13.7	1.73	.38	.69	5 15
Chestnuts,	1	45.0	1.18	.63	.39	3 79
V. Flour and Meal.						
Corn meal,	3	14.1	1.92	.34	.71	5 59
Corn and cob meal,	29	9.0	1.41	.47	.57	4 37
Wheat flour,	2	12.1	2.02	.36	.35	5 52
Ground barley,	1	13.4	1.55	.34	.66	4 65
Pea meal,	1	8.9	3.08	.99	.82	9 12
Soy-bean meal,	1	10.8	5.89	2.23	1.57	17 80
Peanut meal,	1	8.0	7.84	1.54	1.27	21 50
VI. By-products and Refuse.						
Cotton-seed meal,	24	8.2	6.70	1.83	2.47	20 13
Linseed meal (old process),	4	8.0	5.39	1.21	1.78	15 75
Cleveland linseed meal,	5	8.0	5.83	1.25	1.70	16 76
Gluten meal (Chicago),	2	9.6	6.04	.06	.43	14 74
Gluten meal (King),	1	7.8	5.69	.08	.69	14 36
Gluten meal (variety uncertain),	5	8.5	5.09	.05	.42	12 64

* See note on page 251.

B. Fertilizing Ingredients in Fodder Articles — Concluded.

NAME.	Analyses.	Water.	Nitrogen.	Potassium Oxide.	Phosphoric Acid.	Valuation per 2,000 Pounds.*
VI. By-products and Refuse — Con.						
Gluten feed (Buffalo),	5	8.2	3.72	.06	.34	$9 29
Atlas gluten feed,	1	11.2	4.80	.16	.23	11 89
Dried brewers' grain,	2	8.6	3.65	.85	1.05	10 76
Wheat bran,	10	9.9	2.36	1.40	2.10	8 95
Louisiana rice bran,	1	10.3	1.43	.84	1.71	5 81
Wheat middlings,	2	10.2	2.75	.75	1.25	8 48
Rye middlings,	1	12.5	1.84	.81	1.26	6 36
Buckwheat hulls,	1	11.9	.49	.52	.07	1 76
Cotton hulls,	3	10.6	.75	1.08	.18	3 05
Proteina,	1	10.1	2.97	.57	1.00	8 59
Rye feed,	1	9.6	1.95	.98	1.56	7 06
Peanut feed,	2	10.0	1.46	.79	.23	4 50
Peanut husks,	1	13.0	.80	.48	.13	2 52
Damaged wheat,	1	13.1	2.26	.51	.83	6 68
Glucose refuse,	1	6.7	3.37	.09	.61	8 73
Cocoa dust,	1	7.1	2.30	.63	1.34	7 36
Broom-corn waste (stalks),	1	10.4	.87	1.86	.46	4 36
Corn cobs,	8	12.1	.50	.60	.06	1 85
Palmetto roots,	1	11.5	.54	1.38	.16	2 82
Meat meal,	1	8.0	11.21	.30	.73	27 86
VII. Dairy Products.						
Buttermilk,	1	91.1	.51	.05	.04	1 31
Skim-milk,	22	90.3	.59	–	–	–
Whey,	1	93.7	.10	.07	.17	47

* See note on page 251.

C. *Analyses of Dairy Products (Per Cent.).*

	Analyses.	Solids.			Fat.			Curd.	Salt.	Ash.
		Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.			
Whole milk,	2,173	18.27	10.20	13.52	7.54	1.72	4.20	3.51 [1]	-	.71 [2]
Skim-milk,	354	10.48	7.68	9.48	1.02	.05	.32	-	-	-
Buttermilk,	31	9.86	6.83	8.33	.38	.11	.27	-	-	-
Cream (from Cooley process),	203	32.78	18.12	26.10	25.00	10.53	17.60	-	-	.62
Cream (concentrated commercial),	2	50.12	48.71	49.41	45.63	32.20	42.33 [3]	-	-	-
Butter (salted),	39	92.89	85.35	89.21	89.05	81.43	84.36	1.17	3.43	-
Butter (fresh),	14	85.36	72.49	82.24	85.05	72.21	81.48	.76	-	-
Whole-milk cheese (Jersey),*	1	-	-	62.84	-	-	37.32	22.13	-	3.39
Whole-milk cheese,*	1	-	-	64.17	-	-	34.34	26.69	-	3.14
Cheese from milk skimmed after twelve hours' standing,*	1	-	-	62.70	-	-	27.81	30.37	-	4.52
Cheese from milk skimmed after twenty-four hours' standing,*	1	-	-	57.76	-	-	23.42	31.99	-	2.35
Cheese from milk skimmed after thirty-six hours' standing,*	1	-	-	56.05	-	-	17.67	33.24	-	5.14
Cheese from milk skimmed after forty-eight hours' standing,*	1	-	-	54.59	-	-	15.77	34.94	-	3.88
Cheese from skim-milk, with addition of buttermilk,*	1	-	-	51.62	-	-	18.35	28.63	-	4.64
Genuine oleomargarine cheese,*	1	-	-	62.10	-	-	31.66	25.94	-	4.50

* From analyses made in 1875: [1] Average of 42 determinations; [2] Average of 8 determinations; [3] Average of 5 determinations.

TABLES OF THE DIGESTIBILITY OF AMERICAN FEED STUFFS.

EXPERIMENTS MADE IN THE UNITED STATES.

COMPILED BY J. B. LINDSEY.

I. EXPERIMENTS WITH RUMINANTS.

II. EXPERIMENTS WITH SWINE.

DEC. 31, 1896.

TABLES OF THE DIGESTIBILITY OF AMERICAN FEED STUFFS.

I. Experiments with Ruminants.

KIND OF FODDER.	Number of Different Samples.	Number of Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Cellulose (Per Cent.).	Crude Fat (Per Cent.).	Crude Protein (Per Cent.).	Extract Matter (Per Cent.).
Hay and Dry Coarse Fodders.								
Timothy hay (in bloom),	3	5	55.6—65.7 60	56.4—66.8 60	55.8—62.1 58	51.5—61.8 57	50.3—60.4 56	57.5—71.8 63
Timothy hay (past bloom),	5	10	47.0—61.1 53	48.4—62.3 54	37.2—56.8 47	34.6—61.1 53	38.8—50.4 45	55.6—66.9 60
Timothy hay (average all trials),	12	26	57	58	52	60	48	63
Hay of mixed grasses (medium in protein*),	1	2	-	-	49	50	40	58
Hay of mixed grasses (rich in protein),	6	20	54—62 58	- -	56—66 60	44—57 48	56—64 58	56—63 59
Rowen (mixed grasses),	1	4	- -	63—67 65	65—68 66	44—50 46	68—70 69	63—68 65
Rowen (chiefly timothy),	1	4	- -	62—67 64	62—73 66	48—51 49	66—69 68	60—65 63
Average (both samples),	-	-	-	65	66	47	68	64
Salt hay of black grass (*Juncus Gerardi*),	1	2	57—62 60	- -	57—64 60	37—46 41	62—63 63	53—59 56
High-grown salt hay (largely *Spartina juncea*),	1	2	51—55 53	- -	46—55 50	42—51 47	62—63 63	52—55 53
Branch grass (*Spartina juncea*, with *Spartina stricta*, var. *glabra*),	1	2	55—57 56	- -	48—56 52	27—36 31	61—63 62	54—55 54
Low meadow fox grass (*Spartina juncea*),	1	2	52—54 53	- -	49—53 51	17—30 24	- 57	51—52 52

Meadow, swale or swamp hay,	1	2	38—40 39	- -	30—36 33	- 44	31—37 34	- 46
Hay of vetch and oats,	1	2	58—58 58	- -	65—67 66	17—20 19	60—61 60	54—54 54
Clover and timothy hay (poorly cured),	1	2	54.3—55.3 55	- -	52—54.4 53	- 58	37.5—37.9 38	- 60
Hungarian hay,	1	2	64.3—65.8 65	65.9—66.8 66	66.8—68.5 68	- 64	- 60	66.9—67.4 67
Hay of blue-joint grass (past bloom) (*Calamagrostis Canadensis*),	1	1	40	42	37	37	57	43
Hay of blue-joint grass (bloom),	1	2	66.7—70.5 69	68.1—71.5 70	71.5—73.4 72	51.4—53.3 52	68.2—72.3 70	66.4—70.9 69
Hay of orchard grass (ten days after bloom),	1	1	54	56	58	54	59	54
Hay of orchard grass (stage not given),	1	2	57.5—60 59	- -	60—66.7 64	55.4—57.4 56	60—60.8 60	55.3—57.3 56
Average of both samples,	2	3	56	56	61	55	60	55
Hay of red top,	2	3	57.6—62.3 60	59.3—63.6 61	60.8—61.8 61	44.2—58.8 51	60.4—62.4 61	59.1—65.2 62
Dried pasture grass,	1	1	71	-	77	60	72	73
Oat straw,	1	2	49—51.7 50	50.8—53.2 52	57.2—58 58	35.5—41 38	- -	51.8—54.6 53
Barley hay,	1	4	59	62	62	41	65	63
Hay of Legumes.								
Soy-bean hay,	1	2	61.9—62.7 62	- -	59.5—62.1 61	18.7—39.7 29	70.1—72.1 71	66.1—71.5 69
Peanut-vine hay,	1	2	59.5—60.2 60	- -	51.2—52.6 52	62.1—69.8 66	63—63.6 63	69.3—69.7 70

---

* Below 10 per cent.

Table of the Digestibility of American Feed Stuffs — Continued.

KIND OF FODDER.	Number of Different Samples.	Number of Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Cellulose (Per Cent.).	Crude Fat (Per Cent.).	Crude Protein (Per Cent.).	Extract Matter (Per Cent.).
Hay of Legumes — Concluded.								
Cow-pea-vine hay (fair quality),	1	2	- 59	- -	41.2—44.6 43	46.4—53.7 50	63.9—65.1 65	- 71
Clover hay (late bloom, fair quality),	1	2	54.4—55.5 55	55.9—56.4 56	43.8—49 46	51.8—54.8 53	49.3—59.1 55	63.3—64.8 64
Clover hay (good quality),	1	2	50.8—53.5 52	51.6—54.3 53	46.6—49 48	40—48 43	47—52.2 49	56.8—58.9 58
White clover hay (bloom),	1	1	66	67	61	51	73	70
Scarlet clover hay (*T. incarnatum*),	3	9	56.8—65.4 62	52—58 56	32—58.1 45	29—54 44	64—73 69	52—73.6 62
Alsike clover (*T. hybridum*),	2	3	61.1—64.3 62	62—65.2 63	51—58.7 53	35.1—69.3 50	64—69.2 66	66.5—74.1 71
Alfalfa (lucerne) (late bloom),	1	2		-	49	54	77	64
Alfalfa (lucerne) (stage not given),	1	1	-	-	43	48	69	72
Corn Plant (partially Air Dry).								
Corn stover,	1	4	61.1—62 62	- -	64.8—68.3 67	48.1—55.8 52	49.6—54.8 52	62.5—64.5 64
Corn stover (shredded, fed dry),	1	2	57	-	65	72	38—42 40	56
Corn stover (shredded, fed wet),	1	2	59—62 60	- -	69—70 70	73—76 74	33—39 36	57—61 59

Corn stover (average all tests),	3	8	60	-	67	62	45	61
Corn stover (tops and blades),	1	2	59—60.5 60	- -	71.1—71.7 71	70.6—71.9 71	54.2—56.6 55	61.9—62.6 62
Corn stover (leaves of),	1	2	54.8—56.2 56	- -	54.3—67 61	60.6—65.4 63	43.1—68.8 56	57.1—60.6 59
Corn stalk (below ear),	1	2	64—69 67	- -	71—75 74	79—80 80	15—27 21	65—73 69
Topped stover (part above ear),	1	2	52—58 55	- -	69—72 71	62—65 64	17—27 22	50—57 54
Corn husks,	1	2	71—73 72	- -	78—81 80	23—42 33	24—35 30	75 -
Corn leaves (below ear),	1	2	62—67 65	- -	75—80 78	52—59 56	28—41 35	66—70 68
Flint corn fodder (ears just forming),	1	3	69—72 70	71—73 71	72—73 72	63—71 67	69—73 70	71—73 71
Flint (mature) field corn fodder,	4	9	68—73 71	71—75 73	69—80 76	59—77 70	59—79 65	69—78 73
Dent (mature) field corn fodder,	6	14	57—70 66	- -	43—68 57	64—82 76	30—61 48	61—81 72
Average both kinds,	-	-	68	-	65	74	55	73
Dent (in milk) field corn fodder,	5	11	58.8—66 63	- -	50—71 64	67—79 75	44—51 50	61—69 66
Dent (immature, Burrill and Whitman, coarse),	1	4	51—64 57	- -	45—74 59	66—84 76	20—36 27	57—66 61
Dent (immature, no ears formed),	4	8	61—70 65	63—71 67	63—77 71	59—72 66	57—67 62	57—70 64
Sweet corn fodder (mature),	3	6	60—71 67	62—74 70	70—77 74	63—71 74	54—73 64	57—73 68

Table of the Digestibility of American Feed Stuffs — Continued.

KIND OF FODDER.	Number of Different Samples.	Number of Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Cellulose (Per Cent.).	Crude Fat (Per Cent.).	Crude Protein (Per Cent.).	Extract Matter (Per Cent.).
Miscellaneous Dry Substances.								
Hay of wild oat grass (*Danthonica spicata*),	2	3	59.6—68.3 64	61.2—69.1 65	65.1—70.6 68	38.2—62.8 50	48.6—68 58	62.1—68.8 65
Hay of witch grass (*Triticum repens*),	2	4	59.9—62.7 61	61—64.3 62	56.4—67.6 62	53.6—60 57	49.5—64.2 58	62.1—69.9 66
Hay of buttercups (*Ranunculus acris*),	1	2	56	57	41	70	56	67
Hay of white weed (*Leucanthemum vulgare*),	1	2	58	58	46	62	58	67
Cats-tail millet (*Pennesetum spicatum*),	1	2	61.1—63.6 62	- -	64.7—68.4 67	44.7—47.6 46	60.6—64.6 63	58.3—60 59
Johnson-grass hay,	1	1	55	-	58	39	45	54
Sorghum fodder (leaves),	1	2	59.9—66.3 63	- -	64.9—75.9 70	46.3—47.1 47	59.5—62.2 61	62.5—66.6 65
Sorghum bagasse,	1	1	61	-	64	46	14	65
Cotton-seed hulls (fed alone),	4	13	35—47.5 41	- -	.54—57.6 47	58.2—89.3 79	.00—24.6 6	12.9—45.7 34
Cotton-seed hulls when fed with cotton-seed meal (7 to 1 and 6 to 1),	1	3	41 -	- -	33—40 38	- 78	- -	48—50 49
Cotton-seed hulls when fed with cotton-seed meal (4 to 1 to 1½ to 1),	3	11	43—48 45	- -	43—50 46	66—80 76	- -	49—57 51
Cotton-seed feed (hulls and meal, 7 to 1 and 6 to 1),	1	3	45—46 46	- -	34—40 37	81—82 82	44—46 45	50—51 50
Cotton-seed feed (hulls and meal, 4 to 1 to 1½ to 1),	3	11	52—56 55	- -	43—49 46	84—86 85	61—65 62	49—56 54

Green Fodders.								
Dent corn fodder (immature),	4	11	64—74 68	- -	60—76 67	37—83 68	56—80 66	64—79 71
Dent corn fodder (in milk),	3	9	70	-	64	78	61	76
Dent corn fodder (glazing),	5	9	67	-	51	78	54	75
Dent corn fodder (mature),	2	4	65	-	55	73	51	72
Average (glazing and mature),	7	13	66	-	52	76	53	74
Dent corn fodder (ears glazing, Burrill and Whitman, coarse),	1	2	51—54 52	- -	46—47 46	74—82 78	20—28 24	57—61 59
Sweet corn fodder (milk),	1	2	77—78 77	- -	74—76 75	73—74 74	77—78 77	80—81 81
Sweet corn fodder (ears roasting stage), (Storrs),	3	6	- -	67—79 72	54—72 60	76—82 79	52—69 62	73—82 77
Early amber sorghum (just after blossom)	1	2	60.9—61.7 61	- -	41.7—45.3 42	67 -	37.7—42.5 40	70.4—70.8 71
Sorghum in blossom (variety not stated),	1	2	73.1—73.3 73	- -	74—75 75	81.3—81.6 81	51.1—55.7 53	78.2—78 78
Average both samples,	2	4	67	-	59	74	46	74
Green grass (young),	1	1	69	-	74	55	65	72
Same (dry),	1	1	71	-	77	60	71	73
Pasture grass,	1	2	71.9—75.6 74	- -	74.6—76.5 76	74—74.9 74	74—76.5 75	73.8—77.1 75
Average of three samples,	-	-	71	-	76	63	70	73
Rowen grass (mostly Timothy two-thirds grown),	1	2	- -	65—67 66	60—68 64	51—55 52	72—72 .72	67—68 68
Barley fodder (bloom),	2	4	- -	62—71 67	49—66 61	56—63 60	69—73 72	69—76 71

Table of the Digestibility of American Feed Stuffs — Continued.

KIND OF FODDER.	Number of Different Samples.	Number of Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Cellulose (Per Cent.).	Crude Fat (Per Cent.).	Crude Protein (Per Cent.).	Extract Matter (Per Cent.).
Green Fodders — Concluded.								
Oat fodder (bloom ?),	1	2	- -	63—65 64	58—63 60	68—71 70	75—76 75	63—63 63
Rye fodder (formation of head),	1	2	73—74 74	- -	80—80 80	74—74 74	79—80 79	70—71 71
Hungarian grass (early to late bloom),	3	8	61—67 63	61—74 68	65—76 70	48—85 62	59—72 63	64—71 67
Peas and barley (full bloom),	1	2	- -	55—65 60	38—49 43	54—65 60	73—81 77	56—67 61
Peas and oats (bloom ?),	1	2	- -	67—69 68	54—61 57	73—74 74	81—82 81	66—67 66
Clover fodder (late blossom),	1	2	65—67 66	- -	52—53 53	63—66 65	66—68 67	76—79 78
Clover rowen (mostly clover late bloom),	1	2	- -	60—62 61	51—54 52	60—61 61	61—62 62	64—68 65
Scarlet clover (late bloom),	1	3	- -	68—70 69	54—58 56	63—69 66	77—77 77	74—75 74
Average three samples,	3	7	-	-	54	64	70	72
Soy-bean fodder (before bloom, August),	1	2	- -	64—67 66	45—55 50	50—58 54	77—80 79	71—73 72
Soy-bean fodder (seed half grown),	1	2	- -	61—63 62	38—43 41	49—59 54	68—71 69	72—75 73
Cow-pea fodder (ready for soiling),	1	2	- -	76—76 76	57—58 57	56—62 59	73—75 74	84—84 84
Canada peas (just before bloom),	1	2	- -	71—72 71	62—62 62	50—55 52	81—83 82	71—71 71

Corn Silage.								
Dent silage (immature),	5	13	60—68 64	- -	71—78 70	64—85 71	42—65 54	60—70 66
Dent silage (milk to mature),	6	17	60—74 64	- -	45—80 62	78—90 85	45—63 52	63—73 69
Dent silage (stage uncertain, North Carolina),	1	4	53—67 60	- -	43—64 56	55—79 70	19—34 24	61—76 68
Flint silage (ears glazing),	4	11	68—78 75	66—80 77	75—79 77	- 82	48—73 65	71—83 79
Fine crushed silage (steers),	1	2	60.4—68 64	- -	72—78 75	75—77 76	32—44 38	60—70 65
Fine crushed silage (sheep),	1	2	51.5—56 54	- -	59.5—67.7 64	67.5—69 68	21—22 21.5	52.6—57.3 55
Corn silage (raw, ears mature),	1	1	-	-	59	86	45	71
Same (cooked),	1	1	-	-	70	87	39	75
Sweet corn ensilage (occasional ears mature),	1	2	66.6—69.6 68	68.5—71.7 70	68.4—73.7 71	82.3—84.6 83	52.7—55.2 54	70.7—73 72
Soy-bean ensilage (goats),	1	2	52—66 59	- -	47—62 55	66—77 72	71—80 76	46—58 52
Soy-bean ensilage (steers),*	1	2	50—50 50	- -	42—44 43	47—52 49	54—56 55	61—61 61
Cow-pea ensilage (steers),	1	4	59—60 60	- -	50—54 52	62—64 63	57—58 57	72—73 72
Barn-yard millet and soy-bean ensilage (sheep),†	1	4	54—65 59	- -	61—73 69	69—75 72	55—62 57	54—63 59
Corn and soy-bean ensilage (sheep),†	1	3	66—72 69	- -	59—73 65	80—84 82	63—67 65	73—78 75

---

* Must have been very mature as results are exceptionally low. See green soy bean.

† Millet was *P. crus-galli* (Japan). Corn was Pride of the North (medium dent). Soy bean was medium green.

Table of the Digestibility of American Feed Stuffs — Continued.

KIND OF FODDER.	Number of Different Samples.	Number of Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Cellulose (Per Cent.).	Crude Fat (Per Cent.).	Crude Protein (Per Cent.).	Extract Matter (Per Cent.).
Roots, Tubers, etc.								
Potatoes,	1	3	73.3—80.1 77	74.6—81.2 78	- -	13 -	43.4—45.4 44	87.3—93.4 91
Sugar beets,	1	2	94.2—94.8 95	97.6—99.9 99	88.5—113 100	46.4—53.5 50	90—92.6 91	99.8—100 100
Mangolds,	1	2	77.1—80 79	82.7—87 85	26.8—58.8 43	- -	69.7—79.8 75	90.8—91.9 91
English flat turnips,	1	2	90.7—94.9 93	93.2—99 96	89.2—117 100	82.5—92.5 98	84.5—95 90	96—97 97
Ruta-bagas,	1	2	84.4—90 87	89.2—93 91	61—87.5 74	76.8—91.6 84.2	74.7—85.9 80.3	94.4—95.1 95
Grains and Seeds.								
Corn meal (maize),	2	5	83—98 88	- -	- -	80—98 92	40—77 60	85—100 93
Corn and cob meal,	1	3	74—83 79	- -	2—86 45	82—85 84	43—65 52	86—91 88
Pea meal,	1	2	85—88 87	86—89 88	25—26 26	52—57 55	80—86 83	93—94 94
Raw cotton seed,	1	2	63—69 66	- -	65—86 76	- 87	66—70 68	49—50 50
Roasted cotton seed,	1	2	53—58 56	- -	62—69 66	68—75 72	44—50 47	50—52 51
Soy-bean meal,	2	10	75—82 79*	- 78	- -	81—90 85	- 87	- 73
Cotton seed meal,	2	6	67—82 76	- -	32 -	87—100 93	83—96 88	44—75 64

By-products.								
Cleveland linseed meal,	1	3	73—83 80	- -	49—100 74	90—98 93	86—88 85	82—87 84
Old-process linseed meal (National Linseed Oil Company),	1	3	75—82 79	- -	38—71 57	85—92 89	86—93 89	76—79 78
Gluten meal,	1	2	85—90 87	86—92 89	- 33	86—90 88	83—90 87	88—94 91
Chicago gluten meal,	1	2	87—89 88	- -	- -	92—94 93	87—91 89	93—94 93
King gluten meal,	1	2	79—82 81	- -	- -	91—97 94	- 91	78—81 79
Pope cream gluten meal,	1	2	92—95 93	- -	- -	96—99 98	83—84 84	85—91 88
Average all gluten meals,	4	8	87	-	-	93	88	88
Buffalo gluten feed (one lot),	1	2	76—80 78	- -	40—46 43	81—82 81	84—86 85	78—84 81
Buffalo gluten feed (another lot),	1	2	87—88 87	- -	84—94 89	92—95 93	87—87 87	87—87 87
Peoria gluten feed,	1	2	84—87 86	- -	59—97 78	76—82 79	81—85 83	90—90 90
Pope gluten feed,	1	2	86—87 87	- -	76—78 77	79—82 81	85—88 86	90—90 90
Average all gluten feeds,	4	8	84	-	72	83	85	87
Chicago maize feed,	1	2	83—85 84	- -	68—76 72	90—90 90	83—84 84	84—87 85
Atlas gluten meal (feed),	1	2	80—80 80	- -	?- ?-	90—92 91	73—73 73	84—85 84
Winter wheat bran,	1	3	57—66 62	- -	- 27	51—80 64	75—79 77	62—76 65

---

* For two sheep only.

Table of the Digestibility of American Feed Stuffs — Concluded.

KIND OF FODDER.	Number of Different Samples	Number of Single Trials.	Dry Matter (Per Cent.).	Organic Matter (Per Cent.).	Crude Cellulose (Per Cent.).	Crude Fat (Per Cent.).	Crude Protein (Per Cent.).	Extract Matter (Per Cent.).
By-products — Concluded.								
Spring wheat bran,	1	2	62—63 63	- -	22—25 24	76—76 76	78—82 80	70—71 70
Average all wheat bran,	5	11	61	63	22	68	79	69
Wheat middlings,*	1	2	72.6—72.2 75	75.1—79.3 77	- -	84.1—86.1 85	78.4—79.4 79	80.7—84.5 83
Wheat middlings,*	1	2	79.48—85.63 83	- -	32.57—40.06 36	81.71—87.98 85	81.83—87.75 85	84.43—91.08 88
Rice meal,	1	2	71—76 74	- -	? ?	91—92 91	- 62	89—95 92
Rye meal,	1	2	85—90 87	- -	- -	63—65 64	83—85 84	89—94 92
Peanut feed,	1	2	32—32 32	- -	10—13 12	89—90 90	70—71 71	41—58 49
Malt sprouts,	1	1	67	68	34	100	80	69
Dried brewers' grains,	1	2	62—62 62	- -	50—55 53	89—93 91	78—81 79	59—59 59
Corn cobs,	1	2	59—60 59	- -	65—66 65	44—56 50	13—22 17	60—60 60

II. Experiments with Swine.

Maize kernels (whole),	1	1	83	83	38	46	69	89
Maize meal,	2	2	89.5—89.7 90	91.3—92.1 92	29.4—48.7 39	77.6—81.7 80	86.1—89.9 88	93.9—94.2 94
Maize meal (with cobs),	1	1	76	77	29	82	76	84
Pea meal,	1	1	90	92	78	50	89	95
Barley meal,	1	1	80	80	49	57	81	87
Wheat (whole),	1	?	72	-	30	60	70	74
Wheat (cracked),	1	?	82	-	60	70	80	83
Wheat shorts,	1	2	74—79 77	- -	25—48 37	- -	71—75 73	85.5—88 87
Wheat bran,	1	2	53.7—68.6 61	- -	29.6—39.1 34	65.4—78.1 72	74.4—75.8 75	56—75 66
Potatoes,	1	4	97	-	-	-	84	98

---

* Probably different products.

LITERATURE.

The following publications have been consulted in compiling the tables of the digestibility of American feed stuffs: —

Reports of Storrs (Connecticut) Experiment Station, 1894, 1895.

Reports of the Maine State Experiment Station for 1886, 1887, 1888, 1889, 1890, 1891, 1893, 1894.

Reports of the New York Experiment Station, 1884, 1888, 1889.

Reports of the Pennsylvania Experiment Station, 1887, 1888, 1889, 1890, 1891, 1892, 1893.

Bulletins Nos. 80 *c*, 81, 87 *d*, 97 and 118 of the North Carolina Experiment Station.

Bulletin No. 16, Utah Experiment Station.

Bulletin No. 3 of the Wisconsin Experiment Station for 1884, and Sixth Annual Report, 1889.

Bulletin No. 8 of the Colorado Experiment Station.

Bulletins Nos. 26 and 36 of the Minnesota Experiment Station.

Bulletin No. 6 of the Oregon Experiment Station.

Bulletins Nos. 13, 15 and 19 of the Texas Experiment Station.

Bulletins Nos. 20 and 41 of the Maryland Experiment Station.

Eleventh and Twelfth Annual Reports (1893 and 1894) of the Massachusetts State Experiment Station.

Report of Hatch Experiment Station, 1895, 1896.

Bulletin No. 43 of the Illinois Experiment Station.

REPORT OF THE CHEMIST.

DEPARTMENT OF FERTILIZERS AND FERTILIZER MATERIALS.

Charles A. Goessmann; Assistants: H. D. Haskins, R. H. Smith

Part I. Field Experiments.

1. Experiments to study the effect of raising leguminous crops in rotation with grain crops on the nitrogen sources of the soil.
2. "Nitragin," a germ fertilizer for the cultivation of leguminous crops.
3. Observations with leguminous crops at Amherst.
4. Mixed annual forage crops *v.* clovers.
5. Experiments to study the economy of using natural phosphates in place of acid phosphates (superphosphates).
6. Experiments to ascertain the influence of different mixtures of chemical fertilizers on the character and yield of garden crops.

Part II. Work in the Chemical Laboratory.

1. Report on inspection of commercial fertilizers.
2. New laws for the regulation of trade in commercial fertilizers.
3. Report on general work in the laboratory.
4. Compilation of analyses of manurial substances, fruits, garden crops and insecticides.

PART I.

REPORT ON FIELD EXPERIMENTS.

CHARLES A. GOESSMANN.

1. FIELD EXPERIMENTS CARRIED ON FOR THE PURPOSE OF STUDYING THE EFFECT OF A LIBERAL INTRODUCTION OF CLOVER-LIKE PLANTS — LEGUMINOUS CROPS — INTO FARM PRACTICE, AS A MEANS OF INCREASING THE RESOURCES OF AVAILABLE NITROGEN PLANT FOOD IN THE SOIL UNDER CULTIVATION FROM THE ELEMENTARY NITROGEN OF THE AIR. (*Field A.*)

The observation of the fact that the different varieties of clover and of clover-like plants in general, as peas, beans, vetches, lupines, etc., are in an exceptional degree qualified, under favorable conditions, to convert, by the aid of certain micro-organisms of the soil, the elementary nitrogen of the air into plant food, imparts to that class of farm crops a special interest from an economical stand-point. This circumstance is in a controlling degree due to the following two causes: —

First. — The nitrogen-containing soil constituents of plant food are, as a rule, in a high degree liable to suffer serious changes in regard to their character and fitness as well as in reference to their quantity.

Second. — Available nitrogen-furnishing manurial substances are the most costly articles of plant food in our markets.

Field experiments which propose to show, by their results, to what extent the cultivation of clover-like plants can be relied on as a practical and economical means for securing efficiently nitrogen plant food for the crops to be raised have deservedly of late engaged the most careful attention of agricultural investigators.

The systematic treatment of the field here under consideration (Field A), as far as suitable modes of cultivation and of manuring are concerned, was introduced during the season of 1883 to 1884.

The subdivision of the entire area into eleven plats "one-tenth of an acre each," of a uniform size and shape, 132 feet long and 33 feet wide, with an unoccupied and unmanured space of 5 feet in width between adjoining plats, has been retained unaltered since 1884.

A detailed statement of the temporary aim and general management of the experiments, as well as of the results obtained in that connection from year to year, forms a prominent part of my contemporary printed annual reports, to which I have to refer for further details, 1884–96.

Our observations upon Field A are divided into three periods: —

(*a*) Study of the existing soil resources of plant food, 1884 to 1889.

(*b*) Study of the effect of excluding nitrogen plant food from outside sources and of adding nitrogen plant food in various available forms, 1889 to 1892.

(*c*) Studying the effect of the cultivation of leguminous crops on the resources of available nitrogen plant food in the soil under treatment, 1892 to 1897.

The first four years of the stated period 1884 to 1889 were principally devoted to an investigation into the general character and condition of the soil under cultivation as far as its natural and inherent resources of available phosphoric acid, nitrogen and potash were concerned.

The soil proved to be in particular deficient in potash. Different varieties of corn (maize) were raised in succession to assist in the investigation.

Since 1889 the main object of observation upon the same field has been to study the influence of an entire exclusion of any additional nitrogen-containing manurial substance from the soil under cultivation, as well as of a definite additional supply of nitrogen in different forms of combination on the character and yield of the crop selected for the trial.

Several plats (4, 7 and 9) which for five preceding years (1884 to 1889) had not received any nitrogen compound for manurial purposes, were retained in that state, to study the effect of an entire exclusion of nitrogen-containing manurial substances on the crop under cultivation; while the remaining ones received, as before, a definite amount of nitrogen in the same form in which they had received it in preceding years, namely, either as sodium nitrate (1, 2), as ammonium sulphate (5, 6, 8), as organic nitrogenous matter in form of dried blood (3, 10), or of barn-yard manure (0).

A corresponding amount of available nitrogen was applied in all these cases.

1889–94.

PLATS.	Annual Supply of Manurial Substances per Plat (1-10 of one Acre).
Plat 0,	800 lbs. of barn-yard manure, 32 lbs. of potash-magnesia sulphate and 18 lbs. of dissolved bone-black.
Plat 1,	29 lbs. sodium nitrate (= 4 to 5 lbs. nitrogen), 25 lbs. muriate of potash (= 12 to 13 lbs. potassium oxide), and 50 lbs. dissolved bone-black (= 8.5 lbs. available phosphoric acid).
Plat 2,	29 lbs. sodium nitrate (= 4 to 5 lbs. nitrogen), 48.5 lbs. potash-magnesia sulphate (= 12 to 13 lbs. potassium oxide), and 50 lbs. dissolved bone-black (= 8.5 lbs. available phosphoric acid).
Plat 3,	43 lbs. dried blood (= 5 to 6 lbs. nitrogen), 25 lbs. muriate of potash (= 12 to 13 lbs. potassium oxide), and 50 lbs. dissolved bone-black (= 8.5 lbs. available phosphoric acid).
Plat 4,	25 lbs. muriate of potash (= 12 to 13 lbs. potassium oxide) and 50 lbs. dissolved bone-black (= 8.5 lbs. available phosphoric acid).
Plat 5,	22.5 lbs. ammonium sulphate (= 4 to 5 lbs. nitrogen), 48.5 lbs. potash-magnesia sulphate (= 12 to 13 lbs. potassium oxide), and 50 lbs. dissolved bone-black (= 8.5 lbs. available phosphoric acid).
Plat 6,	22.5 lbs. ammonium sulphate (= 4 to 5 lbs. nitrogen), 25 lbs. muriate of potash (= 12 to 13 lbs. potassium oxide), and 50 lbs. dissolved bone-black (= 8.5 lbs. available phosphoric acid).
Plat 7,	25 lbs. muriate of potash (= 12 to 13 lbs. potassium oxide) and 50 lbs. dissolved bone-black (= 8.5 lbs. available phosphoric acid).
Plat 8,	22.5 lbs. ammonium sulphate (= 4 to 5 lbs. nitrogen), 25 lbs. muriate of potash (= 12 to 13 lbs. potassium oxide), and 50 lbs. dissolved bone-black (= 8.5 lbs. available phosphoric acid).
Plat 9,	25 lbs. muriate of potash (= 12 to 13 lbs. potassium oxide) and 50 lbs. dissolved bone-black (= 8.5 lbs. available phosphoric acid).
Plat 10,	43 lbs. dried blood (= 5 to 6 lbs. nitrogen), 48.5 lbs. potash-magnesia sulphate (= 12 to 13 lbs. potassium oxide), and 50 lbs. dissolved bone-black (= 8.5 lbs. available phosphoric acid).

Amount of Fertilizing Ingredients used annually per Acre.

Plats 0, 1, 2, 3, 5, 6, 8, 10,	Nitrogen,	45 pounds.
	Phosphoric acid,	80 pounds.
	Potassium oxide,	125 pounds
Plats 4, 7, 9,	Nitrogen,	none.
	Phosphoric acid,	80 pounds
	Potassium oxide,	125 pounds.

The mechanical preparation of the soil, the incorporation of the manurial substances, the seeding, cultivating and harvesting, were carried on year after year in a like manner, and as far as practicable on the same day in case of every plat during the same year.

Kind of Crops raised.

Corn (maize), ...	in 1889.
Oats, ...	in 1890.
Rye, ...	in 1891.
Soy bean, ...	in 1892.

The annual yield of the various crops upon the different plats showed, as a rule, that those plats (4, 7, 9) which had not received in any form nitrogen for manurial purposes yielded much smaller crops than those that annually received in some form or other an addition of a corresponding amount of available nitrogen.

The total yield of crops on the plats receiving no nitrogen supply was, during the succeeding years, as follows: —

With corn in 1889, one-fifth less.

With oats in 1890, one-fifth to one-sixth less.

With rye in 1891, one-fifth to one-sixth less.

With soy bean in 1892, one-third to one-fourth less.

The results of four years (1889 to 1892) of observations were expressed in the following conclusions: —

The experiments carried on upon Field A during the years 1889, 1890, 1891 and 1892 show conclusively the importance of a liberal supply to the soil of an available form of nitrogen to secure a successful and remunerative cultivation of farm crops under otherwise corresponding favorable conditions. For even a leguminous crop, the soy bean, when for the first time raised upon Field A, did not furnish an exception to our observation (1892). (For details, see report for 1892.)

1893–97. — Subsequent to the year 1892, when for the first time in the more recent history of the field under discussion an *annual leguminous crop*, a late-maturing variety of soy bean, had been raised upon it, it seemed of interest to ascertain whether the raising of *the soy bean* upon Field A had increased the amount of available nitrogen stored up in the soil to such an extent as to affect the yield of succeeding crops upon those plats (4, 7, 9) which, as a rule, had not received at any time for eight successive years an addition of available nitrogen from any other manurial source but the atmospheric air and the roots left in the soil after harvesting the crops raised.

A grain crop (oats) was selected as the crop suitable to serve for that purpose. The general management of the experiment, as far as the preparation of the soil, manuring and seeding-down are concerned, was the same as in previous years (see tenth annual report).

An examination of the yield of the crop in 1893, secured upon the different plats, showed that the total crop per acre on those plats to which no nitrogen was applied (4, 7, 9) averaged 800 pounds less than in case of the plats which received their regular supply of nitrogen in some form or other. The average yield of oats upon the plats (4, 7, 9) which had received no nitrogen supply from any outside source was *from one-seventh to one-eighth less in weight* than the average yield of the remaining plats, which received annually additional nitrogen supply.

From these results it appeared that the introduction of an annual leguminous crop into our rotation had somewhat reduced the difference in yield between the plats receiving no nitrogen and those receiving it, yet had not entirely obliterated it. It was decided to continue the observation by repeating the raising of soy beans in 1894, oats in 1895 and soy beans in 1896.

1894. — To secure, if possible, more decisive results regarding the presence and absence of available nitrogen, it was decided to use twice the amount of phosphoric acid and potassium oxide, as compared with the preceding years.

Amount of Fertilizing Ingredients applied per Acre during 1894.

Plats 0, 1, 2, 3, 5, 6, 8, 10,	Nitrogen,	45 pounds.
	Phosphoric acid,	160 pounds.
	Potassium oxide,	250 pounds.
Plats 4, 7, 9,	Nitrogen,	none.
	Phosphoric acid,	160 pounds.
	Potassium oxide,	250 pounds.

An early-maturing variety of soy bean was selected for the experiments. The fertilizer mixtures were applied as in previous years, broadcast, in the middle of April. Owing to the protracted drought of July and August the crop did not get that fulness of growth which might have been obtained under more favorable conditions. The crop was cut August 28.

The difference in the average yield of crop between the plats (4, 7, 9) which thus far had received no available nitrogen from outside manurial sources, as compared with that from those which had received it in some form or other, was more marked than in previous years. It amounted to one-third in favor of the latter.

1895. — In 1895 oats were again selected, as stated above, to succeed soy bean, for the reason of permitting a direct comparison of the results of 1892 (soy bean) and 1893 (oats) with those of 1894 (soy bean) and 1895 (oats).

The ploughing, manuring, seeding down, etc., was carried out in the same manner as during the preceding season (1894).

The average yield of the plats with and without nitrogen supply from outside sources showed that no material change in their relative degree of productiveness had taken place.

1896. — It was decided to substitute in our experiment a perennial leguminous plant, medium red clover, for the annual leguminous plant, the soy bean, to ascertain whether more satisfactory results will be secured from that change.

As a few years' observation are required to obtain a satisfactory basis for reliable conclusions, reports are deferred.

2. EXPERIMENTS WITH "NITRAGIN," A GERM FERTILIZER FOR THE CULTIVATION OF CLOVER AND CLOVER-LIKE PLANTS.— LEGUMINOUS CROPS.

The history of progress in agriculture shows that a more general and liberal introduction of clover and clover-like plants, as beans, peas, vetches, etc., as forage crops, into a general system of farm management has everywhere increased the chances of a more remunerative farming. The valuable investigations of Laws and Gilbert have furnished striking proofs of the special claims of these crops as nitrogen gatherers when compared in that direction with grain crops.

The subsequent important discovery of the real cause of the exceptional behavior of these crops by Hellriegel and others has given not only a satisfactory explanation of previous observations in practical agriculture but has also imparted, for economical reasons, an increased interest in the study of successful methods of raising clovers, etc., without the aid of a liberal supply of nitrogen-containing manurial substances.

Hellriegel and his co-laborers established by careful observation the fact that leguminous plants, like clovers, beans, vetches, lupines, etc., with the assistance of certain micro-organisms (root bacterium) found in the soil, can utilize the elementary nitrogen of the air for the formation of nitrogen plant food fit for the support of their growth.

These micro-organisms fasten themselves upon the roots of the clover, etc., penetrate the epidermis and form in the course of their growth swellings, nodules or tubercles, of varying size and shape. Their presence and growth in the tissue of the roots of this stated class of plants is considered an essential condition for the conversion of the elementary nitrogen of the air into suitable nitrogen plant food. The recognition of the circumstance that their presence or absence in the soil controls the results in a material degree, even under otherwise favorable conditions, has turned the attention of progressive agriculturists towards the study of the circumstances which secure success.

Quite prominent among the more recent results of investigation in this direction are the observations that a variety of root bacterium exists; that some infest the roots of one kind of leguminous plant while others thrive upon other kinds: that is to say, some leguminous crops may fail to give satisfactory returns where others prosper on account of the presence or absence of the right variety of root bacterium, or of suitable condition of the soil for their vigorous development.

These results caused the introduction of various modes of infecting the soil, wherever found necessary, with the desired kind of bacterium germ, before seeding down the new crop. A very common method consisted in scattering a certain amount of soil, taken from a field where the crop to be raised has been successfully grown, over the surface of the new land before ploughing it. This method has been successfully practised by us on various occasions. Another is to abstract with water some of the soil, which from previous observation is known to contain the desired root bacterium germs, and sprinkle the watery extract over the soil before ploughing.

One of the latest developments in this direction is the appearance in the general market of patented germ fertilizer for leguminous crops. Considering the whole subject from a practical stand-point of sufficient interest, I insert below a copy of a circular received at this office. The connection of two German investigators of excellent reputation with the enterprise invites attention.

Three different kinds of germ fertilizers, for medium red clover, for crimson clover and for sweet or Bokhara clover, have been imported during the past season and are on trial upon the grounds of the station.

NITRAGIN.

Germ Fertilizers for Leguminous Crops.

(Prepared according to Drs. Nobbe and Hiltner.)

The principal food materials abstracted from the soil by plants, and which therefore require to be replaced in the form of manures, are potash, phosphoric acid, lime and nitrogen.

Respecting the last it has been known that leguminous crops, such as clover, vetches, peas, beans, lupines, etc., do not usually require to be manured with nitrogen (in form of nitre or ammoniacal compounds), and yet under favorable conditions yield rich harvests, whilst the soil is even enriched with nitrogen.

The reason of this peculiar behavior for many years remained unexplained, but the onward march of modern science has now demonstrated the ability of leguminous plants to abstract nitrogen from the air, only, however, by the aid of a specific kind of micro-organism, a bacterium that resides in the characteristic nodules on the roots. If these bacteria are not at the disposal of the plant then it looses its ability to utilize the atmospheric nitrogen, and hence it is found that not every leguminous plant is able to flourish luxuriantly without nitrogenous manure; many remain small and stunted under conditions otherwise favorable, and evidently suffer from the lack of nitrogen.

It is therefore a matter of extreme importance to the farmer to make certain that each field of legumes is supplied with the necessary quantum of bacteria; only then can he expect to obtain full crops from poor sandy soils without nitrogen manures (i. e., without saltpetre, ammonia, etc.), and only then will he reap the advantage of a soil enormously enriched with nitrogen.

The wide bearing of this newly discovered principle has already been taken into practical consideration, and fields are now inoculated, that is to say, strewn with earth in which legumes have already flourished. This method, however, apart from its great cost and the loss of time and labor entailed, also involves the danger of disseminating injurious as well as useful bacteria.

This disadvantage is, however, now completely overcome by the pure patent germ fertilizer Nitragin, which consists of a pure cultivation of the specific bacteria of legume nodules in a suitable medium.

The inoculation of the seed or of the soil with the germ fertilizer, according to the directions given below, possesses the following advantages: —

1. Every single seed is surrounded with bacteria which, after germination, penetrate the root hairs and commence their role as collectors of nitrogen, so that a good crop is secured in the poorest soil without nitrogenous manures.
2. Through the storage of nitrogen by the bacteria, the soil itself becomes richer in nitrogen in an assimilable state, to the advantage of the other crops grown in rotation.
3. The disadvantages of the mode of inoculation previously adopted are avoided.
4. Manuring with nitrogen in the form of saltpetre, ammonium salts, etc., is absolutely unnecessary.

Directions for Use.

Every bottle contains sufficient for inoculation of 2½ roods.

If the contents of the bottle have already become liquid, they are used as described below for the direct inoculation of the seed. If solid, the contents can be easily liquefied by warming the bottle gently for a few minutes, for instance, in the trousers' pocket, in tepid water or in a warm room. *Exposure to temperature above the heat of the body, which is amply sufficient to melt, or to direct sunlight must under all circumstances be strictly avoided.*

The liquid contents are poured into a vessel containing one to three pints of clean water (carefully washing out the whole contents of the bottle with a little water), and then shaken or stirred until the fertilizer is equally distributed throughout the vessel and the bacteria are well mixed in the water.

The inoculated water thus prepared is poured over the seed and worked with the hands (or the shovel) until every seed has been moistened. If the quantity of water is insufficient more must be added, but usually for small seed a pint and a half will suffice and for large seeds two to three quarts. The moistened seed is then reduced to a condition suitable for sowing by mixing with some dry sand or fine earth and if necessary allowing it to stand, turning it over from time to time; too great dryness is deleterious. The sowing and turning in is carried out in the manner usually practised. If possible, however, avoid sowing in glaring sunlight.

Instead of inoculating the seed, the same and, in some cases, better results are obtained by inoculating the soil by means of inoculated earth. For this purpose for every 2½ roods one-half a hundred weight of earth is inoculated in the above-described manner, using a proportionately larger quantity of water; the inoculated earth is then dried in the air or mixed with dried earth, scattered equally over the field, and worked in three or four inches deep.

For larger surfaces than 2½ roods a corresponding number of bottles must be used (8 bottles to 5 acres).

As the bacteria are absolutely innocuous, there is no fear of danger from the bottles being left about or employed for other purposes.

Attention is specially directed to the fact that the "germ fertilizers" should only be used for the species of Leguminosæ marked on the label of the bottle. For greater distinction the bottles bear differently colored labels.

Manufactured by the Farbwerke vorm. Meister Lucius & Bruning, Hoechst on Main, Germany.

Specification of the Various Kinds of "Nitragin" (registered) Germ Fertilizers for Leguminous Crops.

Common pea (*Pisum sativum*), red label.
Sand pea (*Pisum arvense*), red label.
Common vetch (*Vicia sativa*), blue label.
Hairy vetch (*Vicia villosa*), blue label.
Common field bean or horse bean (*Vicia faba*), blue label.
White lupine (*Lupinus albus*), green label.
Yellow lupine (*Lupinus lutens*), green label.
Blue lupine (*Lupinus angustifolus*), green label.
Clover, red (*Trifolium pratense*), label gold on green.
White clover or Dutch clover (*Trifolium repens*), label gold on green.

Alsike clover (*Trifolium hybridum*), label gold on green.
Carnation clover or trifolium (*Trifolium incarnatum*), label gold on green.
Bokhara clover (*Melilotus alba*), label gold on green.
Black medick (*Medicago lupulina*), label gold on white.
Lucerne (alfalfa) (*Medicago sativa*), label gold on white.
Kidney vetch (*Anthyllis vulneraria*), label gold on white.
Sainfoin (*Onobrychis sativa*), gold label on violet.
Serradella (*Ornithopus sativus*), label gold on pink.
Wild everlasting pea (*Lathyrus sylvestris*), label gold on blue.

When giving your esteemed orders for Nitragin we shall thank you to state always, for what kind of leguminous crops you wish to receive the germ fertilizers.

Yours respectfully,
FARBWERKE VORM. MEISTER LUCIUS & BRUNING.

3. OBSERVATIONS WITH LEGUMINOUS CROPS AT AMHERST.

The cultivation of leguminous crops has for years received special attention at our hands. The majority of reputed leguminous forage crops congenial to our climate have been raised repeatedly and on a sufficiently large scale in most instances to form a fair opinion regarding their merits as forage crops in our section of the country.

The following statement contains the kinds of leguminous crops experimented with at Amherst: —

Medium red clover (*Trifolium medium*).
Alsike clover (*Trifolium hybridum*).
Crimson clover (*Trifolium incarnatum*).
Japanese clover (*Lespedeza striata*).
Bokhara clover (sweet clover) (*Melilotus alba*).
Serradella (*Ornithopus sativus*).
Sainfoin (*Onobrychis sativa*).
Alfalfa (*Medicago sativa.*)
Scotch tares.
Lentil (*Ervum lens*).
Summer vetch (*Vicia sativa*).
Kidney vetch (*Anthyllis vulneraria*).
Horse bean (*Vicia faba*).
Early-maturing soy bean (*Soja hispida*).
Late-maturing soy bean (*Soja hispida*).
Peas (*Pisum sativum*).
Cow pea (*Dolichos sinensis*).
Flat pea (*Lathyrus sylvestris*).
White lupine (*Lupinus albus*).
Yellow lupine (*Lupinus luteus*).
Blue lupine (*Lupinus perennis*).

For details I have to refer to previous annual reports.

The following local observations are worth mentioning again on this occasion: —

(*a*) Alfalfa (*Medicago sativa*) and crimson clover (*Trifolium incarnatum*), in repeated trials, suffered seriously from winter-killing. This result has to be ascribed more to late frosts early in spring, when the ground is filled with water, than to the severity of mid-winter.

(*b*) Mixed crops of peas, vetch and horse bean, and vetch and oats or barley have given, as a rule, very satisfactory returns as far as quality and quantity are concerned.

(*c*) Soy beans, early and late varieties, have yielded, as a rule, during average seasons large crops; yet they have failed to enrich the soil they were raised upon sufficiently in available nitrogen plant food to secure under otherwise corresponding conditions, as far as the supply of available potash and phosphoric acid is concerned, as high a yield of a succeeding crop of rye, oats, barley and even soy bean, as where from forty to fifty pounds per acre of an available form of nitrogen were added. The liberal addition of nitrates to the soil interfered with a liberal development of root tubercles, in case of soy bean, in a well-infected soil.

Similar results are reported by other investigators in regard to lupines followed by oats or potatoes; an addition of nitrates in connection with a potash and phosphoric acid containing fertilizer increased the yield. The infection of the soil by lupine bacterium did not benefit the growth of other leguminous crops.

The belief that each variety of leguminous crop is associated with a root bacterium of its own finds support in the circumstance that the root tubercles of different varieties of these crops quite frequently vary, not only in size and shape but in their mode of distribution over the main roots or rootlets. Illustrations of this feature have been furnished by the writer in form of photographs from nature in case of soy bean, horse bean, lupines, etc., (see State station report for 1894).

Much has been learned regarding the symbiotic or combined life of root bacteria and leguminous plants, yet much further investigation in the vegetation house and the field is evidently needed *to secure to the full extent* and with certainty the economical advantages to be derived from the raising of crops which are capable of converting, without expense, the elementary nitrogen of the air into available nitrogen plant food.

Our attention, as will be seen from preceding statements, has been of late directed to the question *whether perennial leguminous crops, as our current varieties of clovers,* may prove more satisfactory as nitrogen gatherers for general farm purposes than annual leguminous crops, as soy bean, lupines, etc.

4. Mixed Annual Forage Crops v. Clovers (*Field B*).

The importance of a more liberal and economical supply of nutritious forage crops for the support of farm live stock is quite generally recognized by all parties interested.

Mixed forage crops, consisting of early-maturing annual leguminous crops, clover-like plants and of either oats or barley, suggested themselves for trial; for they attain in our locality a high feeding value at a comparatively early period of the season, — towards the end of June when in bloom; they can serve with benefit in form of green fodder, hay or ensilage, as circumstances advise; they yield under fair conditions large quantities of fodder of a highly nutritious character, and permit a timely reseeding and maturing of a second crop upon the same lands.

The fields used for our earlier observations, in 1893–94, were located in different parts of the farm. They were, as a rule, in a fair state of cultivation, as far as the mechanical condition of the soil as well as its store of plant food was concerned. The soil consisted in the majority of cases of a somewhat gravelly loam (see reports for 1893–94).

The field used in the experiments, subsequently described somewhat in detail, consisted of a light loam and was divided into eleven plats of corresponding shape with four feet of unoccupied space between them. It was used for the cultivation of potatoes in preceding years. The plats had received on that occasion in all cases the same amount and form of nitrogen and phosphoric acid, in form of ground bones, while the potash supply consisted in alternating order of plats either of muriate of potash or of high-grade sulphate of potash, containing the same amount of potassium oxide in every case (400 pounds of muriate of potash, 80 to 82 per cent., or of high-grade sulphate of potash, 95 per cent., and 600 pounds of fine-ground bones per acre). This system of manuring the plats has been followed ever since 1893. The same crops have been raised each season upon adjoining plats to notice the particular effect of both forms of potash on the crop raised (for details see previous reports).

Vetch and Oats and Vetch and Barley.

1894. — The same amount and kind of manure were applied for raising vetch and oats and vetch and barley. The field occupied by these crops was ploughed, manured, harrowed and seeded down, as far as practicable, at the same time. The seed was sown in all cases April 26. Four bushels of oats with 45 pounds of vetch were sown, as on previous occasions, while 3 bushels of barley were used with 45 pounds of vetch per acre in case of barley and vetch. Both crops came up May 4 and were of a uniformly healthy condition during their subsequent growth. The barley began to head out June 20; the vetch was at that time beginning to bloom. The crop was cut for hay June 23.

It needs no further statement to understand that the quality of the seeds and of the soil ought to be considered in deciding about weights of the former. Close cultivation is desirable in case of this class of forage crops, for it favors a succulent, tender structure and keeps weeds out.

Average Yield of Crops.

Yield of Barley and Vetch per Acre.

In case of muriate of potash and bone, . .	5,737 pounds of hay.
In case of sulphate of potash and bone, . .	5,077 pounds of hay.

The oats headed out June 25; the vetch was fairly in bloom at this time. The crop was cut for hay July 2.

Yield of Oats and Vetch per Acre.

In case of muriate of potash and bone, . .	8,051 pounds of hay.
In case of sulphate of potash and bone, . .	7,088 pounds of hay.

1895. — During that year the observations of the preceding year were repeated and in some directions enlarged; oats, vetch and horse bean, and oats and lentils were added to those of the preceding year. The same kind and quantity of manures were applied. The field was ploughed April 25 and the manure harrowed in May 3; the seed was sown broadcast May 9. All parts of the field were treated alike, and as far as practicable on the same day. The plats occupied by the crops were in all cases 33 feet wide, with 4 feet unoccupied space between them, and from 191 to 241 feet long. The yield of areas 175 feet long and 33 feet wide, running along by the side of each other, served as our basis for comparing results (5,775 square feet) (for details see report for 1895).

Yield of Vetch and Oats per Acre.

In case of muriate of potash and bone, ...	7,238 pounds.
In case of sulphate of potash and bone, ...	6,635 pounds.

Yield of Vetch, Horse Bean and Oats per Acre.

In case of muriate of potash and bone, ...	7,398 pounds.
In case of sulphate of potash and bone, ...	5,881 pounds.

Yield of Oats and Lentils per Acre.

The experiment was confined to a trial with sulphate of potash and bone as manure on account of want of a suitable field. The yield was 5,881 pounds of hay.

After the crops stated had been harvested, during the middle of July, in the form of hay, the field was ploughed and prepared for the cultivation of a variety of clovers, mammoth red clover, medium red clover, alsike or Swedish clover, crimson clover and sweet or Bokhara clover, to compare the crops resulting during two succeeding years with those obtained in case of mixed crops of vetch and oats, etc.

The subdivision of the field into eleven plats was the same as in the preceding year; each plat received the same kind and amount of fertilizer as before; the mechanical preparation of the soil was in all cases the same. The seeding down of the different plats took place on the same day, July 23, 1895.

Plats 11 and 12 were each seeded down with 3 pounds of sweet clover seed.

Plats 13 and 14 were each seeded down with 3 pounds of mammoth red clover seed.

Plats 15 and 16 were each seeded down with 3 pounds of medium red clover seed.

Plats 17 and 18 were each seeded down with 2½ pounds of alsike or Swedish clover seed.

Plats 19 and 20 were each seeded down with 4 pounds of crimson or scarlet clover.

Plats 11, 13, 15, 17 and 19 received their potash in form of muriate of potash (80 to 82 per cent.); plats 12, 14, 16, 18 and 20 in form of high-grade sulphate of potash (95 per cent.).

Subsequent History of Crops on Different Plats.

Plats 11 and 12. — The frost affected the crop somewhat by heaving of the soil; the growth was thin and of a light color except in some instances where a deep color and large growth was noticed. A subsequent examination showed in these cases an exceptional development of tubercles on the roots. The crop was harvested June 19.

Plat 11. — Crop weighed green 200 pounds.

Plat 12. — Crop weighed green 285 pounds.

On account of unsatisfactory condition of the plats both were ploughed July 15 and reseeded on July 30, 1896, with 10 pounds of sweet clover seed each, to notice whether a more liberal infection of the soil with suitable bacterium thus secured would result in better and larger returns. Nov. 1, 1896, the crop was looking well and was one foot in height. The dark spots of growth had spread greatly.

Plats 13 and 14. — The crops upon these plats looked well in the fall and during the succeeding spring. The crop was cut before it had reached full bloom, June 23, on account of its being badly lodged; they were harvested as hay June 29.

Total Yield of Hay.

PLATS.	Yield of Hay (Pounds).	Yield of Rowen (Pounds).	Total Yield of Dry Matter (Pounds).
13,	615	295	756.65
14,	650	305	796.32

The sod looked well on both plats Nov. 1, 1896.

Plats 15 and 16. — The crop looked healthy in the fall and in the succeeding spring; the crop was cut when in full bloom, June 19, and harvested June 23. The rowen was cut July 28 and harvested July 30. A third crop was cut October 9 and harvested October 26.

Total Yield of Hay.

PLATS.	Yield of Hay (Pounds).	Yield of Second Crop (Pounds).	Yield of Third Crop (Pounds).	Total Yield of Dry Matter (Pounds).
15,	455	276	120	686.62
16,	455	294	120	720.55

The sod looked to be in good condition on both plats Nov. 1, 1896.

Plats 17 and 18. — The crop looked well from the beginning and was in bloom June 7. The hay was cut and harvested June 19 and 23.

Total Yield of Hay.

PLATS.	Yield of Hay (Pounds).	Yield of Rowen (Pounds).	Total Yield of Dry Matter (Pounds).
17,	620	325	733.21
18,	455	200	518.56

Nov. 1, 1896, the sod looked exhausted and was covered with weeds and sorrel.

Plats 19 and 20. — These plats looked well in early winter but almost every plant died out in early spring. The plats were reseeded during the month of April, 1896, with 5½ pounds of seed on each plat. The hay was cut when in bloom July 17 and harvested July 23. The crop was in poor condition when cut and never sprouted again.

Total Yield of Hay.

PLATS.	Yield of Hay (Pounds).	Total Yield of Dry Matter (Pounds).
19,	575	422.91
20,	595	406.94

Summary of Yield of Crops in 1896 (Dry Matter).

[Pounds.]

PLATS.	Hay.	Rowen.	Total Yield of Dry Matter.
11,	–	–	–
12,	–	–	–
13,	511.62	245.03	756.65
14,	541.58	254.74	796.32
15,	373.46	313.16	686.62
16,	390.12	330.43	720.55
17,	458.49	274.72	733.21
18,	356.54	162.02	518.56
19,	422.91	–	422.91
20,	406.94	–	406.94

5. FIELD EXPERIMENTS WITH DIFFERENT COMMERCIAL PHOSPHATES, TO STUDY THE ECONOMY OF USING THE CHEAPER NATURAL PHOSPHATES OR THE MORE COSTLY ACIDULATED PHOSPHATES. (*Field F.*)

The field selected for this purpose is 300 feet long and 137 feet wide, running on a level from east to west. Previous to 1887 it was used as a meadow, which was well worn out at that time, yielding but a scanty crop of English hay. During the autumn of 1887 the sod was turned under and left in that state over winter. It was decided to prepare the field for special experiments with phosphoric acid by systematic exhaustion of its inherent resources of plant food. For this reason no manurial matter of any description was applied during the years 1887, 1888 and 1889.

The soil, a fair sandy loam, was carefully prepared every year by ploughing during the fall and in the spring, to improve its mechanical condition; during the same period a crop was raised every year. These crops were selected, as far as practicable, with the view to exhaust the supply of phosphoric acid in particular. Corn, Hungarian grass and leguminous crops (cow pea, vetch and serradella) followed each other in the order stated.

In 1890 the field was subdivided into five plats, running from east to west, each 21 feet wide with a space of 8 feet between adjoining plats. The manurial material applied to each of these five plats contained, in every instance, the same form and the same quantity of potassium oxide and nitrogen, while the phosphoric acid was furnished in each case in the form of a different commercial phosphoric-acid-containing article, namely, phosphatic slag, Mona guano, Florida phosphate, South Carolina phosphate, floats and dissolved boneblack. The market cost of each of these articles in 1890 controlled the quantity applied, for each plat received the same money value of its particular kind of phosphate. The phosphatic slag, Mona guano, South Carolina phosphate, floats and Florida phosphate were applied at the rate of 850 pounds per acre, dissolved bone-black at the rate of 500 pounds per acre. Nitrate of soda was applied at the rate of 250 pounds per acre and potash-magnesia sulphate at the rate of 390 pounds per acre. (For the analysis of phosphates and cost of each in 1890 see report for 1895.)

The following fertilizer mixtures have been applied annually, from 1890 to 1894, to all plats, with the exception of Plat 3, which received in 1890 ground apatite and in 1891 no phosphate whatever, on account of the failure of securing in time apatite suitable for the trial.

PLATS.	Annual Supply of Manurial Substances.	Pounds.
Plat 1 (south, 6,494 square feet),	Ground phosphatic slag,	127
	Nitrate of soda,	43
	Potash-magnesia sulphate,	58
Plat 2 (6,565 square feet),	Ground Mona guano,	128
	Nitrate of soda,	43½
	Potash-magnesia sulphate,	59
Plat 3 (6,636 square feet),	Ground Florida phosphate,	129
	Nitrate of soda,	44
	Potash-magnesia sulphate,	59
Plat 4 (6,707 square feet),	South Carolina phosphate,	131
	Nitrate of soda,	44½
	Potash-magnesia sulphate,	60
Plat 5 (6,778 square feet),	Dissolved bone-black,	78
	Nitrate of soda,	45
	Potash-magnesia sulphate,	61

Names of Crops raised from 1890 to 1894.

1890, potatoes (see eighth annual report of Massachusetts State station); 1891, winter wheat (see ninth annual report of Massachusetts State station); 1892, serradella (see tenth annual report of Massachusetts State station); 1893, Dent corn, Pride of the North (see eleventh annual report of Massachusetts State station).

Summary of Yield of Crops (Pounds).

PLATS.	1890. Potatoes.	1891. Wheat.	1892. Serradella.	1893. Corn.
Plat 1, phosphatic slag,	1,600	380	4,070	1,660
Plat 2, Mona guano,	1,415	340	3,410	1,381
Plat 3, Florida phosphate,	1,500	215	2,750	1,347
Plat 4, South Carolina floats,	1,830	380	3,110	1,469
Plat 5, dissolved bone-black,	2,120	405	2,920	1,322

Having for four years (1890–94) in succession pursued the above-stated system of manuring each plat with a different kind of phosphate, yet of corresponding money value, it was decided to continue the experiments for the purpose of studying the *after-effect* of the different phosphates on the crops to be raised. To gain this end the phosphates were hereafter in all cases entirely excluded from the fertilizers applied; in addition to this change, the former amount of potash and nitrogen was increased one-half in quantity, to favor the highest effect of the stored-up phosphoric acid in the soil under treatment.

The fertilizers hereafter used had the following composition: —

Plat 1 (6,494 square feet),	64½ pounds of nitrate of soda. 87 pounds of potash-magnesia sulphate.
Plat 2 (6,565 square feet),	65¼ pounds of nitrate of soda. 88 pounds of potash-magnesia sulphate.
Plat 3 (6,686 square feet),	66 pounds of nitrate of soda. 89 pounds of potash-magnesia sulphate.
Plat 4 (6,707 square feet),	66¾ pounds of nitrate of soda. 90 pounds of potash-magnesia sulphate.
Plat 5 (6,778 square feet),	67½ pounds of nitrate of soda. 90½ pounds of potash-magnesia sulphate.

The results of three years (1894 to 1896) are as follows: —

Barley.

Yield of Crop (1894).

PLATS.	Grain and Straw (Pounds).	Grain (Pounds).	Straw and Chaff (Pounds).	Percentage of Grain.	Percentage of Straw.
Plat 1,	490	169	221	34.49	65.51
Plat 2,	405	148	251	34.07	65.93
Plat 3,	290	78	212	26.89	73.11
Plat 4,	460	144	216	31.30	68.70
Plat 5,	390	118	272	30.26	69.74

Rye.

Yield of Crop (1895).

PLATS.	Grain and Straw (Pounds).	Grain (Pounds).	Straw and Chaff (Pounds).	Percentage of Grain.	Percentage of Straw.
Plat 1,	695	195	500	28.06	71.94
Plat 2,	631	166	465	26.31	73.69
Plat 3,	383	143	240	37.34	62.66
Plat 4,	759	189	570	24.90	75.10
Plat 5,	625	185	440	29.60	70.40

Medium Green Soy Bean.

Yield of Crop (1896).

PLATS.	Whole Crop (Pounds).	Beans (Pounds).	Straw, etc. (Pounds).	Percentage of Beans.	Percentage of Straw, etc.
Plat 1, ...	680	254	426	37.20	62.80
Plat 2, ...	773	233	540	30.14	69.86
Plat 3, ...	717	262	455	36.54	63.46
Plat 4, ...	752	252	500	33.51	66.49
Plat 5, ...	742	247	495	31.94	68.06

Summary of Yield of Crops (1890 to 1896).

[Pounds.]

PLATS.	1890. Potatoes.	1891. Wheat.	1892. Serradella.	1893. Corn.	1894. Barley.	1895. Rye.	1896. Soy Bean.
Plat 1, phosphatic slag,	1,600	380	4,070	1,660	490	695	254
Plat 2, Mona guano, .	1,415	340	3,410	1,381	405	630	233
Plat 3, Florida phosphate.	1,500	215	2,750	1,347	290	383	262
Plat 4, South Carolina phosphate (floats).	1,830	380	3,110	1,469	460	759	252
Plat 5, dissolved bone-black.	2,120	405	2,920	1,322	390	625	247

Conclusions.

From the previous statement of comparative yields for average successive years we find that the plat receiving dissolved bone-black leads in yield during the first two years while the third, fourth, fifth and sixth years the plats receiving phosphates insoluble in water are ahead, phosphatic slag being first, with South Carolina floats second.

The following statement regarding the phosphoric acid applied in the case of each plat, and also the amount removed from them by the crops raised, shows approximately how much the former is still stored up in the soil in each plat, not considering the original inherent amount in the soil at the beginning of the trial: —

Phosphoric Acid applied to and removed from Field (Pounds).

PLATS.	1890. Potatoes.		1891. Wheat.		1892. Serradella.		1893. Corn.		Total Amount added.	Total Amount removed.	Total Amount remaining.
	Added.	Removed.	Added.	Removed.	Added.	Removed.	Added.	Removed.			
Plat 1, .	24.18	2.56	24.18	1.23	24.18	8.95	24.18	7.20	96.72	19.94	77.78
Plat 2, .	28.01	2.36	28.01	1.19	28.01	7.50	28.01	6.33	72.04	17.38	54.66
Plat 3, .	109.68	2.40	-	.69	28.01	6.05	28.01	5.95	165.70	15.09	150.61
Plat 4, .	36.12	2.93	36.12	1.31	36.12	6.84	36.12	6.68	144.48	18.12	126.36
Plat 5, .	12.34	3.39	12.34	1.22	12.34	6.42	12.34	6.05	49.36	17.08	32.28

Phosphoric Acid applied to and removed from Field (Pounds) — Concluded.

PLATS.	1894. Barley.		1895. Rye.		1896. Soy Bean.		Total Amount added.	Total Amount removed.	Total Amount remaining.
	Added.	Removed.	Added.	Removed.	Added.	Removed.			
Plat 1, . . .	-	1.92	-	3.41	-	5.84	96.72	31.11	65.61
Plat 2, . . .	-	1.64	-	3.04	-	5.75	72.04	27.81	44.23
Plat 3, . . .	-	.76	-	2.06	-	6.07	165.70	23.98	141.72
Plat 4, . . .	-	1.72	-	3.61	-	6.01	144.48	29.46	115.02
Plat 5, . . .	-	1.49	-	3.11	-	5.89	49.36	27.57	21.79

The experiment needs continuation to secure more decisive results.

6. Field Experiments to ascertain the Influence of Different Mixtures of Commercial Fertilizers on the Yield and General Character of Several Prominent Garden Crops.

The area devoted to the above-stated experiment is 198 feet long and 183 feet wide; it is subdivided into six plats of uniform size (89½ by 62 feet, or about one-eighth of an acre each). The plats are separated from each other and from the adjoining cultivated fields by a space of 5 feet of unmanured and unseeded yet cultivated land.

They are arranged in two parallel rows, running from east to west. Plats Nos. 1, 2 and 3 are along the north side of the field, beginning with No. 1 at its west end, while plats Nos. 4, 5 and 6 are located along its south side, beginning with Plat 4 on the west end. The soil is several feet deep, and consists of a light, somewhat gravelly loam, and was in a fair state of productiveness when assigned for the experiment here under consideration. The entire field occupied by the experiment is nearly on a level. Potatoes and a variety of forage crops have been raised upon it in preceding years. The manure applied since 1885 has consisted exclusively of fine-ground bone and muriate of potash, annually, 600 pounds of the former and 200 pounds of the latter per acre.

The observation with raising garden crops by aid of the different mixtures of commercial manurial substances, here under special consideration, began upon plats Nos. 4, 5 and 6 during the spring of 1891, and upon plats Nos. 1, 2 and 3 during that of 1892.

The difference of the fertilizers applied consisted in the circumstance that the different forms of nitrogen and potash were used for their preparation. All plats received essentially the same quantity of nitrogen, potash and phosphoric acid, and every one of them received its phosphoric acid in the same form, namely, dissolved bone-black. Some plats received their nitrogen supply in form of organic animal matter, dried blood; others in form of sodium nitrate, Chili saltpetre; others in the form of ammonium sulphate. Some plats received their potash in the form of muriate of potash (plats 1, 2, 3), and others (plats 4, 5, 6) in the form of the highest grade of potassium sulphate (95 per cent.). The subsequent tabular statement shows the quantities of manurial substances applied to the different plats: —

Plats.	Annual Supply of Manurial Substances.	Pounds.
Plat 1,	Sulphate of ammonia,	38
	Muriate of potash,	30
	Dissolved bone-black,	40
Plat 2,	Nitrate of soda,	47
	Muriate of potash,	30
	Dissolved bone-black,	40
Plat 3,	Dried blood,	75
	Muriate of potash,	30
	Dissolved bone-black,	40
Plat 4,	Sulphate of ammonia,	38
	Sulphate of potash,	30
	Dissolved bone-black,	40
Plat 5,	Nitrate of soda,	47
	Sulphate of potash,	30
	Dissolved bone-black,	40
Plat 6,	Dried blood,	75
	Sulphate of potash,	30
	Dissolved bone-black,	40

This proportion corresponds per acre to: —

	Pounds.
Phosphoric acid (available),	50.4
Nitrogen,	60.0
Potassium oxide,	120.0

A computation of the results of a chemical analysis of twenty prominent garden crops shows the average relative proportion of the three above-stated ingredients of plant food: —

	Per Cent.
Nitrogen,	2.2
Potassium oxide,	2.0
Phosphoric acid,	1.0

One thousand pounds of green garden vegetables contain on the above-stated basis of relative proportion of essential constituents of plant food: —

	Pounds.
Nitrogen,	4.1
Potassium oxide,	3.9
Phosphoric acid,	1.9

The weights and particular stage of growth of the vegetables when harvested control, under otherwise corresponding conditions, the actual consumption of each of these articles of plant food. Our information regarding these points is still too fragmentary to enable a more detailed statement here beyond relative proportions. It must suffice for the present to call attention to the fact that a liberal manuring within reasonable limits pays, as a rule, better than a scanty one, especially in the case of those crops which reach in a short period the desired state of maturity.

The various mixtures of fertilizers used in the experiments under discussion provided by actual supply for one-half of the available nitrogen actually called for to meet the demand as above pointed out. A liberal cultivation of peas and beans cannot fail to benefit the nitrogen resources of the soil. The order of arrangement of the different crops within each plat was the same in all of them for the same year.

They occupied, however, a different position relative to each other in successive years, to introduce, as far as practicable, a system of rotation of crops. (For details see previous annual report.)

Statement of Crops raised since 1891.

1891 and 1892.	1893.	1894.	1895 and 1896.
Celery.	Onions.	Onions.	Onions.
Lettuce.	Lettuce.	Sweet corn.	Sweet corn.
Spinach.	Spinach.	–	–
Beets.	Beans.	Beans.	Beans.
Cabbage.	–	–	–
Tomatoes.	Tomatoes.	Tomatoes.	Tomatoes.
Potatoes.	Potatoes.	–	–

Season of 1896. — The field was ploughed April 20. The fertilizers were the same as in the preceding years; each of the six plats received the same amount and kind of fertilizer, which was harrowed in April 24.

The crops raised during the season of 1896 were: —

Onions (Danvers Globe).
Tomatoes (Dwarf Champion).
Beans (Dwarf Horticultural).
Sweet Corn (Early Crosby).

Onions.

The seed was sown April 28. Each plat contained fifteen rows 14 inches apart; the weeds were kept down by frequent use of the hand cultivator; the crop was weeded by hand twice; the crop was rolled September 7. Those plats (4, 5, 6) which received their potash supply in form of high-grade sulphate of potash matured first, while those plats (1, 2, 3) receiving muriate of potash matured somewhat later. The crop upon Plat 1 was the latest to mature, while that upon Plat 2, receiving nitrate of soda, was the most advanced plat in the field. The onions were pulled September 7, topped October 5 and weighed October 9.

Yield of Onions (Pounds).

PLATS.	Large Onions.	Small Onions.	Scullions.	Total Yield.
Plat 1, . .	490	29	100	628
Plat 2, . .	697	24	30	751
Plat 3, . .	659	49	60	768
Plat 4, . .	489	26	55	570
Plat 5, . .	494	21	30	545
Plat 6, . .	595	54	50	699

Tomatoes.

It was deemed best in this experiment to procure an earlier maturing variety than the one used in the preceding year, to meet our market demands. The plants were started at the plant house of the horticultural department. The plants were set May 21 3 to 4 feet apart, two rows in each plat; each plat contained 44 plants; they were cultivated five times and hand-hoed three times.

Field C. Yield of Tomatoes (Pounds).

DATE OF PICKING.	Plat 1.	Plat 2.	Plat 3.	Plat 4.	Plat 5.	Plat 6.
July 18,	–	–	.40	–	–	.14
July 22,	.40	–	.12	–	–	.12
July 25,	1.10	.30	1.11	.30	.13	.12
July 28,	2.12	1.00	2.80	2.60	2.10	6.40
July 30,	3.20	2.10	2.80	1.14	4.00	3.40
August 1,	4.00	6.00	3.40	5.00	8.00	4.00
August 3,	8.40	6.80	8.80	7.00	5.80	7.00
August 5,	8.12	8.40	9.00	7.60	10.40	9.40
August 8,	10.12	15.00	15.00	13.80	17.00	18.00
August 10,	17.40	13.80	11.00	14.00	12.12	19.40
August 12,	7.40	8.80	5.00	12.00	13.40	9.40
August 15,	13.80	25.00	21.40	34.00	32.12	25.12
August 17,	17.00	44.80	21.12	45.00	49.40	36.12
August 19,	9.00	16.80	22.40	17.00	22.12	17.12
August 21,	6.12	14.80	18.40	7.80	15.40	8.40
August 24,	12.80	31.00	18.80	21.80	39.40	30.40
August 26,	13.12	33.80	17.00	20.00	35.80	26.80
August 29,	Not weighed.*	36.00	Not weighed.*	32.00	33.40	27.12
September 1,		50.80		49.12	68.40	53.00
September 4,		55.80		61.00	63.40	77.00
September 7,		48.80		44.00	54.00	63.00
September 11,		37.00		46.80	47.40	51.12
September 16,		34.00		55.00	35.00	42.00
September 21,		7.00		10.00	9.80	12.00
Green tomatoes,	28.00	10.80	40.00	24.00	9.00	14.00

* Records not complete.

Beans.

The beans were planted in rows 2½ feet apart, there being seven rows in each plat. The seed was planted May 19, the young plants appeared above ground June 1; they were cultivated five times and hand-hoed three times; the beans on all plats alike rusted badly. The beans were pulled and stacked in the field August 19.

Yield of Beans (Pounds).

PLATS.	Beans.	Pods and Vines.	Total Weight.
Plat 1, ...	31	30	61
Plat 2, ...	53	44	97
Plat 3, ...	52	44	96
Plat 4, ...	58	45	103
Plat 5, ...	67	51	118
Plat 6, ...	48	42	90

Sweet Corn.

Each plat contained five rows, the latter being 3 feet 3 inches apart; the hills were 20 inches apart, there being three plants left in each hill, making 1,060 hills per plat.

The crop appeared above ground June 1. It was subsequently cultivated five times and hand-hoed three times. In order to hasten maturity the stalks were topped September 9.

The corn was harvested and weighed October 9 with the following results: —

Sweet Corn (Early Crosby). Yield in Pounds per Plat.

PLATS.	Ears.	Stover.	Total Weight.
Plat 1, ...	190.0	250	445.0
Plat 2, ...	240.0	280	520.0
Plat 3, ...	195.0	335	530.0
Plat 4, ...	190.0	310	500.0
Plat 5, ...	182.5	290	472.5
Plat 6, ...	190.0	302	492.0

Conclusions drawn from Four Years of Observation.

1. Sulphate of potash in connection with nitrate of soda (Plat 5) has given in every case but one (onions) the best results.

2. Nitrate of soda as nitrogen source (plats 2 and 5) has yielded in almost every case, without reference to form of potash, the best results.

3. Sulphate of ammonia as a nitrogen source, in connection with muriate of potash as source of potash (Plat 1), has given as a rule the least satisfactory returns. This fact is evidently due to a change of chloride of potash and sulphate of ammonia into sulphate of potash and chloride of ammonium, the latter being an unfavorable form of nitrogen plant food.

4. The influence of the difference in the general character of the weather, whether normal or dry, during succeeding seasons on the yield of the crops has been greater than that of the different fertilizers used upon different plats during the same season.

Note. — The general management of the field work connected with the previously described continuation of my experiments was attended to by Mr. H. M. Thomson, Assistant Agriculturist of the Hatch Experiment Station, to whom I take pleasure in expressing my thanks for his cheerful assistance.

PART II.

REPORT ON THE WORK IN THE CHEMICAL LABORATORY.

CHARLES A. GOESSMANN.

1. ON OFFICIAL INSPECTION OF COMMERCIAL FERTILIZERS AND AGRICULTURAL CHEMICALS IN 1896.

During the past year fifty-seven manufacturers and dealers in commercial fertilizers and agricultural chemicals have applied for and secured licenses for the sale of their goods in the State. Thirty-three of these parties have offices for general distribution within our State, nine in the State of New York, six in Connecticut, three in Vermont, three in Rhode Island, two in Pennsylvania and one in Illinois.

The number of distinct brands licensed, including agricultural chemicals, amounted to two hundred and sixty-five.

The sampling and collecting of the material for official analyses were in charge of Mr. H. D. Haskins, a graduate of the Massachusetts Agricultural College of the year 1890, and an efficient assistant in the chemical laboratory of the division of chemistry of the Experiment Station, who for several years in the past has attended to that part of the inspection in a very satisfactory manner.

Three hundred and twenty-eight samples were collected during the year, of which three hundred, representing two hundred and fifteen distinct brands, have been analyzed, and the results published in three bulletins, March, July and October, Numbers 38, 40 and 42 of the Hatch Experiment Station of the Massachusetts Agricultural College.

The modes of analyses adopted in this work were in all essential points those recommended by the Association of Official Chemists.

The results of the inspection have been on the whole quite satisfactory, as far as the compliance of the dealers with the provisions of our State laws for the regulation of the trade in commercial fertilizers is concerned. The variations here and there noticed between the guaranteed composition of the dealer and the results of our analyses could be traced with but few exceptions to imperfect mixing of the several ingredients of the fertilizer, and did not, as a rule, materially affect the commercial value of the article. In this connection attention should be called to the fact that the lowest amount stated in the guarantee is only legally binding.

To convey a more direct idea of the actual condition of this feature in the trade of commercial fertilizers of 1896, the following detailed statement is here inserted: —

(*a*) Where three essential elements of plant food were guaranteed: —

Number with three elements equal to or above the highest guarantee,	3
Number with two elements above the highest guarantee,	18
Number with one element above the highest guarantee,	65
Number with three elements between the lowest and highest guarantees,	26
Number with two elements between the lowest and highest guarantees,	60
Number with one element between the lowest and highest guarantees,	42
Number with two elements below the lowest guarantee,	8
Number with one element below the lowest guarantee,	59

(*b*) Where two essential elements of plant food were guaranteed: —

Number with two elements above the highest guarantee,	–
Number with one element above the highest guarantee,	16
Number with two elements between the lowest and highest guarantees,	13
Number with one element between the lowest and highest guarantees,	10
Number with one element below the lowest guarantee,	10

(*c*) Where one essential element of plant food was guaranteed: —

Number above the highest guarantee,	4
Number between the lowest and highest guarantees,	21
Number below the lowest guarantee,	11

The consumption of commercial fertilizers is steadily increasing, — a circumstance apparently not less due to a more general recognition of their good services, if judiciously selected and applied, than to gradual improvements in regard to their mechanical condition as well as their general chemical character. A noticeable change, referred to already in a previous report, regarding the chemical composition of many brands of so-called complete or formula fertilizers of to-day, as compared with those offered for similar purposes at an earlier period in the history of the trade in commercial fertilizers, consists in a more general and more liberal use of potash compounds as a prominent constituent. This change has been slow but decided, and in a large degree may be ascribed to the daily increasing evidence, resting on actual observations in the field and garden, that the farm lands of Massachusetts are quite frequently especially deficient in potash compounds, and consequently need in many instances a more liberal supply of available potash from outside sources to give satisfactory returns. Whenever the cultivation of garden vegetables, fruits and forage crops constitutes the principal products of the land, this recent change in the mode of manuring deserves in particular a serious trial; for the crops raised consume exceptionally large quantities of potash, as compared with grain crops. In view of these facts, it will be conceded that a system of manuring farm and garden which tends to meet more satisfactory recognized conditions of large areas of land, as well as the special wants of important growing branches of agricultural industries, is a movement in the right direction.

The present condition of the trade in commercial fertilizers offers exceptional advantages to provide efficient manures for the raising of farm and garden crops of every description congenial to soil and climate. The various essential articles of plant food, as potash, phosphoric acid and nitrogen compounds, are freely offered for sale in forms suitable to render the different kinds of the home manurial refuse material of the farm in a higher degree fit to meet the special wants of the crops to be raised.

Mixed fertilizers, designed to supply the essential articles of plant food with reference to the needs of special crops, and containing them in every conceivable proportion, are asking for the patronage of all parties interested in the raising of plants.

A judicious management of the trade in commercial fertilizers implies a due recognition of well-established experimental results regarding the requirements of a remunerative production of farm and garden crops; yet, as the manufacturer at best can only prepare the composition of his special fertilizers on general lines, not knowing the particular condition and character of the soil which ultimately receives them, it becomes of the utmost importance on the part of the farmer to make himself acquainted with his special wants of manurial substances, and to thus qualify himself for a more judicious selection from the various fertilizers offered for his patronage.

For the reason that the physical conditions and chemical resources of soils on available plant food are frequently differing widely even on the same farm, no definite rule can be given for manuring farm lands, beyond the advice to return to the soil those plant constituents which the crops raised during preceding years have abstracted in an exceptionally large proportion, and which at the same time will be especially called for by the crops to be raised.

To select judiciously from among the agricultural chemicals and mixed fertilizers offered for sale for home use requires, in the main, three kinds of information: —

First. — A knowledge of the condition and the character of the soil to be prepared for cultivation.

Second. — An acquaintance with the composition of the crops, as far as the essential elements of plant food they contain are concerned.

Third. — A fair information regarding the general character, as well as the special composition, of the manurial substances offered for sale are concerned.

To assist as far as practicable in obtaining the above-stated desirable information, a compilation of the composition of our most prominent farm and garden crops, as well as the manurial substances and agricultural chemicals found in our markets, has been published from time to time in our annual reports, and will be found at the close of the present one.

List of Manufacturers and Dealers who have secured Certificates for the Sale of Commercial Fertilizers in This State during the Past Year (May 1, 1896, to May 1, 1897), and the Brands licensed by Each.

The Armour Fertilizer Works, Chicago, Ill.: —
- Bone Meal.
- Bone and Blood.
- Ammoniated Bone and Potash.
- All Soluble.
- Bone, Blood and Potash.
- Old Bog Cranberry Manure.

American Fertilizer Company, Boston, Mass.: —
- Anti Acid Phosphate.
- Alkaline Nitrate Phosphate for Hoed Crops.
- Alkaline Nitrate Phosphate for Hay and Grain Crops.
- Ward's Inodorous Plant Food.
- Muriate of Potash.

Wm. H. Abbott, Holyoke, Mass.: —
- Abbott's Fertilizer.
- Abbott's Eagle Brand Fertilizer.

Bartlett & Holmes, Springfield, Mass.: —
- Pure Ground Bone.
- Animal Fertilizer.

H. J. Baker and Brother, New York, N. Y.: —
- Standard Un X Ld Fertilizer.
- Complete Strawberry Manure.
- Complete Onion Manure.
- Complete Potato Manure.
- Complete Corn Manure.
- A A Ammoniated Superphosphate.
- Complete Tobacco Manure.
- Grass and Lawn Dressing.
- Vegetable, Vine and Potato Special.
- Ground Bone.

C. A. Bartlett, Worcester, Mass.: —
- Pure Ground Bone.
- Animal Fertilizer.

The Berkshire Mills, Bridgeport, Conn.: —
- Ammoniated Bone Phosphate.
- Complete Fertilizer.

Bowker Fertilizer Company, Boston, Mass.: —
- Stockbridge Special Manures.
- Bowker's Hill and Drill Phosphate.
- Bowker's Farm and Garden Phosphate.
- Bowker's Lawn and Garden Dressing.
- Bowker's Fish and Potash.
- Bowker's Potato and Vegetable Manure.
- Bowker's Market-garden Manure.
- Bowker's Sure Crop Bone Phosphate.
- Gloucester Fish and Potash.
- Bowker's Dry Ground Fish.
- Bowker's Fresh Ground Bone.
- Nitrate of Soda.
- Dried Blood.
- Dissolved Bone-black.
- Muriate of Potash.
- Sulphate of Potash.
- Sulphate of Ammonia.

Bradley Fertilizer Company, Boston, Mass.: —
- Bradley's X L Superphosphate.
- Bradley's Potato Manure.
- Bradley's B D Sea Fowl Guano.
- Bradley's Complete Manures.
- Bradley's Fish and Potash.
- Bradley's High-grade Tobacco Manure.
- English Lawn Fertilizer.
- Farmers' New Method Fertilizer.
- Breck's Lawn and Garden Dressing.
- Sulphate of Potash.
- Muriate of Potash.
- Nitrate of Soda.
- Sulphate of Ammonia.
- Dissolved Bone-black.
- Fine-ground Bone.

William E. Brightman, Tiverton, R. I.: —
- Brightman's Potato and Root Manure.
- Brightman's Phosphate.
- Brightman's Fish and Potash.

B. L. Bragg & Co., Springfield, Mass. : —
- Hampden Lawn Dressing.

Butchers' Rendering Association, Saugus, Mass. : —
- Ground Bone.
- Champion Garden Fertilizer.

Daniel T. Church, Providence, R. I. : —
- Church's B Special Fertilizer.
- Church's C Standard Fertilizer.
- Church's D Fish and Potash.

Clark's Cove Fertilizer Company, Boston, Mass. : —
- Bay State Fertilizer.
- Bay State Fertilizer, G G Brand.
- Great Plant Manure.
- Potato and Tobacco Manure.
- King Philip Guano.
- Potato Manure.
- Fish and Potash.
- White Oak Pure Ground Bone.
- Muriate of Potash.
- Sulphate of Potash.
- Nitrate of Soda.

The Cleveland Dryer Company, Boston, Mass. : —
- Cleveland Superphosphate.
- Cleveland Potato Phosphate.
- Cleveland Fertilizer.

E. Frank Coe Company, New York, N. Y. : —
- E. Frank Coe's Excelsior Potato Fertilizer.
- E. Frank Coe's High-grade Potato Fertilizer.
- E. Frank Coe's Special Fertilizer.
- E. Frank Coe's High-grade Ammoniated Bone Superphosphate.
- E. Frank Coe's Fish Guano and Potash.
- E. Frank Coe's Bay State Ammoniated Bone Superphosphate.
- E. Frank Coe's Bay State High-grade Potato Fertilizer.

Crocker Fertilizer and Chemical Company, Buffalo, N. Y. : —
- Crocker's General Crop Phosphate.
- Crocker's New England Tobacco Grower.

Crocker Fertilizer and Chemical Company, Buffalo, N. Y. — *Concluded.*
- Muriate of Potash.
- Coolidge Brothers' Special Truck Fertilizer.
- Crocker's Ammoniated Bone Superphosphate.
- Crocker's Potato, Hop and Tobacco Phosphate.
- Crocker's Special Potato Manure.
- Crocker's Pure Ground Bone.
- Crocker's Practical Ammoniated Superphosphate.
- Crocker's New Rival Ammoniated Superphosphate.
- Crocker's Ammoniated Wheat and Corn Phosphate.
- Crocker's Ground Bone Meal.
- Crocker's Vegetable Bone Superphosphate.

Cumberland Bone Phosphate Company, Boston, Mass.: —
- Cumberland Superphosphate.
- Cumberland Potato Fertilizer.
- Cumberland Concentrated Phosphate.
- Cumberland Fertilizer.

L. B. Darling Fertilizer Company, Pawtucket, R. I.: —
- Animal Fertilizer.
- Extra Bone Phosphate.
- Potato and Root Fertilizer.
- Lawn and Garden Fertilizer.
- Tobacco Grower.
- Pure Fine Bone.
- Pure Dissolved Bone.
- Sulphate of Potash.

John C. Dow & Co., Boston, Mass.: —
- Superphosphate.
- Pure Bone.
- Bone Fertilizer.

Fyfe, Fay & Plummer, Clinton, Mass.: —
- Canada Wood Ashes.

Great Eastern Fertilizer Company, Rutland, Vt.: —
- Great Eastern General Fertilizer.
- Northern Corn Special.
- Soluble Bone and Potash.
- Vegetable, Vine and Tobacco Fertilizer.
- Garden Special Fertilizer.

Thomas Hersom & Co., New Bedford, Mass.: —
  Bone Meal.

John G. Jefferds, Worcester, Mass.: —
  Jefferds' Fine Ground Bone.
  Jefferds' Potato Manure.
  Jefferds' Animal Fertilizer.

Thomas Kirley, South Hadley Falls, Mass.: —
  Kirley's Pride of the Valley.

A. Lee & Co., Lawrence, Mass.: —
  The Lawrence Fertilizer.

Lowell Fertilizer Company, Lowell, Mass.: —
  Lowell Bone Fertilizer.
  Lowell Animal Fertilizer.
  Lowell Potato Phosphate.
  Lowell Vegetable and Vine Fertilizer.
  Lowell Lawn Dressing.
  Dissolved Bone and Potash.
  Complete Manure for Potatoes and Vegetables.

Lowe Brothers & Co., Fitchburg, Mass.: —
  Tankage.

The Mapes Formula and Peruvian Guano Company, New York, N. Y.: —
  The Mapes Superphosphates.
  The Mapes Bone Manures.
  The Mapes Special Crop Manures.
  Sulphate of Potash.
  Double Manure Salts.
  Nitrate of Soda.
  Economical Manure.
  Lawn Top-dressing with Plaster.

E. McGarvey & Co., successors to Forest City Wood Ash Company, Boston, Mass.: —
  Unleached Wood Ashes.

McQuade Brothers, West Auburn, Mass.: —
  Pure Ground Bone.

Monroe, Lalor & Co., Oswego, N. Y.: —
  Unleached Wood Ashes.

National Fertilizer Company, Bridgeport, Conn.: —
  Chittenden's Complete Fertilizers.
  Chittenden's Ammoniated Bone.
  Chittenden's Market-garden Fertilizer.
  Chittenden's Fish and Potash.
  Chittenden's Ground Bone.
  Chittenden's Potato Phosphate.

Niagara Fertilizer Company, Buffalo, N. Y.: —
  Niagara Wheat and Corn Producer.
  Niagara Triumph.
  Niagara Grain and Grass Fertilizer.
  Niagara Potato, Tobacco and Hop Fertilizer.

Packers' Union Fertilizer Company, New York, N. Y.: —
  Animal Corn Fertilizer.
  University Fertilizer.
  Oats and Clover Fertilizer.
  Potato Manure.
  Gardeners' Complete Manure.

Pacific Guano Company, Boston, Mass.: —
  Soluble Pacific Guano.
  Special Potato Manure.
  Nobsque Guano.
  Special for Potatoes and Tobacco.
  Fish and Potash.
  High-grade General Fertilizer.

Parmenter & Polsey Fertilizer Company, Peabody, Mass.: —
  Plymouth Rock Brand.
  Special Potato Fertilizer.
  Special Strawberry Manure.
  Star Brand Fertilizer.
  Lawn Dressing.
  Ground Bone.
  Nitrate of Soda.
  Muriate of Potash.

E. W. Perkins & Co., Rutland, Vt.: —
  Plantene.

Prentiss, Brooks & Co., Holyoke, Mass.: —
- Complete Manures.
- Phosphate.
- Nitrate of Soda.
- Dissolved Bone-black.
- Muriate of Potash.
- Sulphate of Potash.
- Fish and Potash.
- Dry Ground Fish.

Preston Fertilizer Company, Green Point, L. I.: —
- Pioneer Fertilizer.
- Ammoniated Superphosphate.
- Potato Fertilizer.

Quinnipiac Company, Boston, Mass.: —
- Potato Manure.
- Market-garden Manure.
- Ammoniated Dissolved Bones.
- Fish and Potash (Crossed Fishes).
- Fish and Potash (Plain Brand).
- Havana Tobacco Fertilizer.
- Grass Fertilizer.
- Corn Manure.
- Potato and Tobacco Fertilizer.
- Onion Manure.
- Pure Bone Meal.
- Dry Ground Fish.
- Tankage.
- Muriate of Potash.
- Sulphate of Potash.
- Nitrate of Soda.
- Sulphate of Ammonia.
- Dissolved Bone-black.
- Phosphate.

Read Fertilizer Company, New York, N. Y.: —
- Read's Standard.
- High-grade Farmers' Friend.
- Fish and Potash.
- Vegetable and Vine Fertilizer.
- Practical Potato Special Fertilizer.

N. Roy & Son, South Attleborough, Mass.: —
  Complete Animal Fertilizer.

The Rogers & Hubbard Company, Middletown, Conn.: —
  Pure Raw Knuckle Bone Flour.
  Strictly Pure Fine Bone.
  Soluble Potato Manure.
  Soluble Tobacco Manure.
  Fertilizer for Oats and Top-dressing.
  Fairchild's Formula for Corn and General Crops.
  Grass and Grain Fertilizer.

Russia Cement Company, Gloucester, Mass.: —
  XXX Fish and Potash.
  High-grade Superphosphate.
  Special Manure for Potatoes, Roots and Vegetables.
  Special Manure for Corn, Grain and Grass.
  Odorless Lawn Dressing.
  Dry Ground Fish.

Lucien Sanderson, New Haven, Conn.: —
  Dissolved Bone-black.
  Muriate of Potash.
  Sulphate of Potash.
  Nitrate of Soda.
  Blood, Meat and Bone.
  Formula A.

M. L. Shoemaker & Co., Limited, Philadelphia, Penn.: —
  Swift and Sure Phosphate.
  Swift and Sure Bone Meal.

Edward H. Smith, Northborough, Mass.: —
  Fine-ground Bone.

Standard Fertilizer Company, Boston, Mass.: —
  Standard Fertilizer.
  Potato and Tobacco Fertilizer.
  Standard Guano.
  Fine-ground Bone.
  Complete Manure.

Thomas L. Stetson, Randolph, Mass.: —
  Fine-ground Bone.

F. C. Sturtevant, Hartford, Conn.: —
  Ground Tobacco Stems.

Henry F. Tucker & Co., Boston, Mass.: —
Original Bay State Bone Superphosphate.
Imperial Bone Superphosphate.
Special Potato Fertilizer.

Walker, Stratman & Co., Pittsburg, Penn.: —
Potato Special.
Four Fold.
Smoky City.
Meadow King.

I. S. Whittemore, Wayland, Mass.: —
Whittemore's Complete Manure.

The Wilcox Fertilizer Works, Mystic, Conn.: —
Potato, Onion and Tobacco Manure.
Ammoniated Bone Phosphate.
High-grade Fish and Potash.
Dry Ground Fish Guano.
Fish and Potash, 1896 Brand.
Low-grade Sulphate of Potash.

Williams & Clark Fertilizer Company, Boston, Mass.: —
Superphosphate.
Potato Phosphate.
High-grade Special.
Fine Wrapper Tobacco Fertilizer.
Royal Bone Phosphate.
Corn Phosphate.
Potato and Tobacco Manure.
Grass Manure.
Fish and Potash.
Universal Ammoniated Dissolved Bone.
Prolific Crop Producer.
Onion Manure.
Pure Bone Meal.
Dry Ground Fish.
Tankage.
Muriate of Potash.
Sulphate of Potash.
Nitrate of Soda.
Dissolved Bone-black.
Sulphate of Ammonia.

M. E. Wheeler & Co., Rutland, Vt.: —
- High-grade Fruit Fertilizer.
- Grass and Oats Fertilizer.
- Electrical Dissolved Bone.
- Potato Manure.
- High-grade Corn Fertilizer.
- Superior Truck Fertilizer.

2. New Laws for the Regulation of the Trade in Commercial Fertilizers in Massachusetts.

[Acts of 1896, Chapter 297.]

An Act to regulate the Sale of Commercial Fertilizers.

Be it enacted, etc., as follows:

Section 1. Every lot or parcel of commercial fertilizer or fertilizer material sold or offered or exposed for sale within this Commonwealth shall be accompanied by a plainly printed statement, clearly and truly certifying the number of net pounds of fertilizer in the package, the name, brand or trade-mark under which the fertilizer is sold, the name and address of the manufacturer or importer, the location of the factory, and a chemical analysis stating the percentage of nitrogen, of potash soluble in distilled water, and of phosphoric acid in available form soluble in distilled water and reverted, as well as the total phosphoric acid. In the case of those fertilizers which consist of other and cheaper materials said label shall give a correct general statement of the composition and ingredients of the fertilizer it accompanies.

Sect. 2. Before any commercial fertilizer is sold or offered or exposed for sale the importer, manufacturer or party who causes it to be sold or offered for sale within this Commonwealth shall file with the director of the Hatch experiment station of the Massachusetts Agricultural College a certified copy of the statement named in section one of this act, and shall also deposit with said director at his request, a sealed glass jar or bottle, containing not less than one pound of the fertilizer, accompanied by an affidavit that it is a fair average sample thereof.

Sect. 3. The manufacturer, importer, agent or seller of any brand of commercial fertilizer or fertilizer material shall pay for each brand, on or before the first day of May annually, to the director of the experiment station, an analysis fee of five dollars for each of the three following fertilizing ingredients: namely, nitrogen, phosphorus and potassium, contained or claimed to exist in said brand of fertilizer: *provided*, that whenever the manufacturer or importer shall have paid the fee herein required for any person acting as agent or seller for such manufacturer or importer, such agent or seller shall not be required to pay the fee named in this section; and on receipt of said analysis fees and statement specified in section two the director of said station shall issue certificates of compliance with this act.

SECT. 4. No person shall sell or offer or expose for sale in this Commonwealth any pulverized leather, hair or wool waste, raw, steamed, roasted or in any form as a fertilizer, or as an ingredient of any fertilizer or manure, without an explicit printed certificate of the fact, said certificate to be conspicuously affixed to every package of such fertilizer or manure, and to accompany or go with every parcel or lot of the same.

SECT. 5. Any person selling or offering or exposing for sale any commercial fertilizer without the statement required by the first section of this act, or with a label stating that said fertilizer contains a larger percentage of any one or more of the constituents mentioned in said section than is contained therein, or respecting the sale of which all the provisions of the foregoing section have not been fully complied with, shall forfeit fifty dollars for the first offence and one hundred dollars for each subsequent offence.

SECT. 6. This act shall not affect parties manufacturing, importing or purchasing fertilizers for their own use and not to sell in this Commonwealth.

SECT. 7. The director of the experiment station shall pay the analysis fees, as soon as received by him, into the treasury of the station, and shall cause one analysis or more of each fertilizer or fertilizer material to be made annually, and shall publish the results from time to time, with such additional information as the circumstances render advisable, provided such information relates only to the composition of the fertilizer or fertilizer material inspected. Said director is hereby authorized in person or by deputy to take a sample, not exceeding two pounds in weight, for analysis, from any lot or package of fertilizer or fertilizer material which may be in the possession of any manufacturer, importer, agent or dealer; but said sample shall be drawn in the presence of said party or parties in interest, or their representative, and taken from a parcel or a number of packages which shall be not less than ten per cent. of the whole lot inspected, and shall be thoroughly mixed and then divided into two equal samples and placed in glass vessels, and carefully sealed and a label placed on each, stating the name or brand of the fertilizer or material sampled, the name of the party from whose stock the sample was drawn, and the time and place of drawing; and said label shall also be signed by the director or his deputy and by the party or parties in interest, or their representatives present at the drawing and sealing of said sample; one of said duplicate samples shall be retained by the director and the other by the party whose stock was sampled. All parties violating this act shall be prosecuted by the director of said station.

SECT. 8. Chapter two hundred and ninety-six of the acts of the year eighteen hundred and eighty-eight is hereby repealed.

SECT. 9. This act shall take effect on the first day of November in the year eighteen hundred and ninety-six. [*Approved April 17, 1896.*]

3. GENERAL WORK IN THE CHEMICAL LABORATORY.

Analyses of materials sent on for examination.

Notes on basic phosphatic slag ("slag meal") as a fertilizer.

Action of chloride of potassium (muriate of potash) and chloride of sodium (common salt) on the lime resources of the soil.

Effect of chloride of potassium on sulphate of ammonium in mixed fertilizers.

Analyses of Materials sent on for Examination.

The constantly increasing variety of waste products of many branches of industry within our State and elsewhere, which have proved of manurial value, has received for years a serious attention. As a change in the current modes of manufacture of the parent industry is at any time liable to seriously affect the character and chemical composition of the waste or by products, it becomes necessary to repeat from time to time analyses of many of these products. These analyses are made, as far as our resources allow, without any charge for the work, on the condition that the results are public property if deemed of interest for publication.

A brief enumeration of the more prominent substances sent on for our investigation during the year 1896 may serve to convey a correct idea concerning the extent and importance of the labor involved. The whole number of substances analyzed in this connection during the year 1896 to December 1 amounts to 175: wood ashes, 51; cotton-seed-hull ashes, 7; swill ashes from cremation furnace, 1; rock phosphate, 4; acid phosphate, 4; phosphatic slag, 2; ground bones, tankage, dried fish and blood, 18; cotton-seed and linseed meal, 19; barn-yard manure, solid and liquid, 11; cotton waste from factories, 6; potash salts of various descriptions, 18; dry Bordeaux mixtures, 10; Paris green, 8; miscellaneous analyses, 10; and compound fertilizers, 21.

The responsibility of the genuineness of all samples sent on for examination rests with the parties asking for analyses; the name of the localities they come from appears only in our published records of the work to prevent misunderstandings. The samples of fertilizers collected by responsible parties under the direction of the officer of this department alone are entered on our list of official analyses.

Notes on Basic Phosphatic Slag ("Slag Meal") as a Fertilizer.

This article appeared for the first time in our markets in 1886 under the name of phosphatic meal made of the Peine-Thomas Scoria, a by-product of a new process introduced into the manufacture of iron and steel from phosphorus containing iron ores.

The first sample received by me at Amherst was marked "R. Weichsel & Co., Magdeburg, Germany; phosphate meal made of the Peine-Thomas Scoria, guaranteed by Dr. Ulex of Hamburg, Germany, to contain 21.41 per cent. of phosphoric acid, corresponding to 46.74 per cent. of bone phosphate; Paul Weidinger & Co., New York, acting as agents."

The first lot sent on for field experiments consisted of 500 pounds of ground slag meal, also a mixture of 500 pounds of slag meal with 500 pounds of kainite; to the latter had been added some dry ground peat, to prevent caking. Pure slag meal, it is claimed, never hardens after being ground.

As the process of dephosphorizing the iron requires that the slag should be alkaline from the beginning, an excess of lime enters into the composition of the slag. To the presence of a certain amount of burned lime the phosphate meal owes, evidently, some of its good effects as a phosphoric acid source for plant food; incorporated in the soil, it absorbs moisture, and, like burned lime, it breaks up into an impalpable powder, which cannot fail to increase the availability of its phosphoric acid in a marked degree, as compared with other non-acidulated ground phosphates.

Not less beneficial must be considered in many instances the alkaline reaction of the genuine material, for it secures favorable conditions not only for a rapid decomposition ("nitrification") of the organic matter of the soil, but also for the disintegration of valuable mineral constituents of the soil, rendering in both directions inherent plant food more available. Much attention has been paid in Germany and England to experiments with slag meal as a phosphoric acid source of plant food, and many satisfactory results are reported. Our own observations are, to say the least, very encouraging, as may be seen from several annual reports since 1887.

Mixtures of phosphatic slag with nitrate of soda and the higher grades of potash salts have given in many instances much satisfaction. To secure the full benefit of the action of slag meal, it is desirable to scatter it broadcast late in the fall or early in the spring, and to plough it under at once from three to four inches; nitrate of soda and potash salts may be harrowed in later on, previous to seeding down.

The high price (from $20 to $25 per ton) of late charged for phosphatic slag meal of a varying composition and general character has discouraged its trial, as compared with the ground phosphate of South Carolina and Florida. As the high price has greatly interfered with a more general trial of slag meal, it is of interest to learn that arrangements are announced which will result in introducing large supplies of it at a much lower cost than before. A German syndicate, claiming to own the right of patent regarding the sale of Thomas slag in Europe and the United States, has established an office in Philadelphia, Penn., address Charles A. Voight, P. O. box 2133, Station A. In a recent communication from him it is stated the article will be offered for sale at from $8 to $9 per ton to farmers in the eastern States. The material consists of a dark, fine powder; it is sent out in 200 pound bags, with a guarantee of 18 per cent. of phosphoric acid. The station has secured a quantity for trial during the coming season.

Analysis of Phosphatic Slag Meal.

[I. Analyses of above-stated sample, 1896; II. Average of four analyses of earlier dates.]

	PER CENT.	
	I.	II.
Moisture, ...	1.45	1.45
Total phosphoric acid, ...	17.88	23.49
Calcium oxide (lime),.	43.74	48.66
Magnesium oxide, ...	–*	3.42
Ferric and aluminic oxides, ...	25.25	10.12
Insoluble matter, ...	9.93	9.40

* Not determined.

Action of Chloride of Potassium (Muriate of Potash) and Chloride of Sodium (Common Salt) on the Lime Resources of the Soil.

In a previous bulletin, No. 38, issued March, 1896, by the Hatch Experiment Station, I called attention to an observation in connection with some field experiments, which showed that in several instances where, under otherwise corresponding circumstances, for several years muriate of potash had been liberally used as a potash source for a variety of crops, instead of sulphate of potash, an unhealthy appearance and lower yield of crop became from year to year more apparent. To correct this feature, from 350 to 400 pounds per acre of dry slacked lime were scattered broadcast over the surface of the soil, and ploughed under before manuring and seeding down the crop. The addition of lime gave excellent satisfaction, for the new crop looked healthy and vigorous, and the yield of the crop increased again fully to the average amount of the field. An examination of the drainage waters confirmed the view taken in the treatment of the field; the chlorides of calcium and magnesium were noticed to form prominent constituents of the solid residue left after its evaporation. The amount of lime noticed in the drainage waters where muriate of potash had been added as a potash source was in every instance larger than where corresponding amounts of high-grade sulphate of potash were applied.

In publishing the results of our observations the following conclusions were offered for the consideration of farmers: —

(*a*) *The claim of both muriate and sulphate of potash, being economical and efficient forms to supply potash for growing crops, is so well established that no further endorsement is called for in this connection. Each form has its special merits with reference to particular fitness in case of different crops.*

(*b*) *The liberal use of muriate of potash as a fertilizer constituent renders, in cases where the lime resources of the soil under cultivation are limited, a periodical direct application of lime compounds as a manurial matter advisable.*

(*c*) *Muriate of potash is a safer source for manurial purposes upon a deep soil with a free subsoil than upon a shallow soil with a compact clayish subsoil, on account of a possible accumulation of the highly objectionable chlorides of calcium and magnesium (lime and magnesia) near the roots of the plants; both are known to prevent a healthy development of the root system.*

Repeated observations in the field and in the laboratory tend to confirm the above-stated conclusions; chloride of sodium (common salt) behaves in the same way as the chloride of potassium, — a fact which is readily proved by adding to any kind of a soil which is free from the chlorides of calcium some ground chalk and common salt, and after a week or so collecting and analyzing the percolating water; the presence of carbonic acid favors greatly the reaction; no good agricultural soil is free from carbonic acid or bicarbonates of lime and magnesium.

Effect of Chloride of Potassium (Muriate of Potash) on Sulphate of Ammonium in Mixed Fertilizers.

In studying the influence of the following mixtures of fertilizing materials, *i. e.*, —

PLATS.	Annual Supply of Manurial Substances.	Pounds.
Plat 1,	Sulphate of ammonia, Muriate of potash, Dissolved bone-black,	38 30 40
Plat 2,	Nitrate of soda, Muriate of potash, Dissolved bone-black,	47 30 40
Plat 3,	Dried blood, Muriate of potash, Dissolved bone-black,	75 30 40
Plat 4,	Sulphate of ammonia, Sulphate of potash, Dissolved bone-black,	38 30 40
Plat 5,	Nitrate of soda, Sulphate of potash, Dissolved bone-black,	47 30 40
Plat 6,	Dried blood, Sulphate of potash, Dissolved bone-black,	75 30 40

on the yield and character of a variety of garden crops, it was noticed, with but one or two exceptions, that the fertilizers on Plat 1, consisting of dissolved bone-black, sulphate of ammonium and muriate of potash, produced the lowest yield of crop on trial; while the fertilizers on Plat 4, composed of corresponding quantities of dissolved bone-black, sulphate of ammonium and high-grade sulphate of potash, yielded, as a rule, a fair average crop. (For details, see preceding annual reports since 1892.)

As the season, character of the soil and mode of cultivation were practically the same in all cases, it seemed but natural to conclude that the fertilizers applied to Plat 1 suffered an unfavorable change when incorporated in the soil. An actual trial proved that a dry mixture of muriate of potash and sulphate of ammonium dissolved in water changes into sulphate of potash and chloride of ammonium (sal ammoniac); this form of nitrogen is known to act unfavorably on growing plants.

Most of our agricultural chemicals are liable to suffer chemical changes when used in mixed fertilizers; these changes are frequently not less depending on a mutual reaction upon each other than on the general character and the particular chemical composition of the soil which receives them. The results of the chemical reactions between the saline constituents of the fertilizers and of the soil are as apt to benefit the crop as to injure it; the above-described observation furnishes an illustration of an injurious influence. Sulphate of ammonium is evidently a safer source of nitrogen for plant growth when used in connection with sulphate of potash than when used with muriate of potash (chloride of potassium).

4. COMPILATION OF ANALYSES OF AGRICULTURAL CHEMICALS, MANURIAL SUBSTANCES, FRUITS, GARDEN CROPS AND INSECTICIDES.

Prepared by H. D. HASKINS, Assistant Chemist,
Hatch Experiment Station.

1868 to 1897.

This compilation does not include the analyses made of licensed fertilizers. They are to be found in the reports of the State Inspector of Fertilizers from 1873 to 1896, contained in the reports of the Secretary of the Massachusetts State Board of Agriculture for those years, and in the bulletins of the department of chemistry of the Hatch Experiment Station of the Massachusetts Agricultural College since March, 1895.

As the basis of valuation changes from year to year, no valuation is stated in this compilation.

C. A. GOESSMANN.

	Analyses.	Moisture.	Ash.	NITROGEN.			POTASH.			TOTAL PHOSPHORIC ACID.			Soluble Phosphoric Acid.	Reverted Phosphoric Acid.	Insoluble Phosphoric Acid.	Soda.	Lime.	Magnesia.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
				Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.											
I. Chemicals, Refuse, Salts, Ashes, etc.																							
Muriate of potash,	81	1.77	–	–	–	–	58.98	45.94	51.00	–	–	–	–	–	–	6.69	–	.55	–	–	–	48.80	.70
Sulphate of potash,	38	1.86	–	–	–	–	51.30	21.36	40.21	–	–	–	–	–	–	4.46	–	1.50	–	45.72	–	–	.75
Sulphate of potash-magnesia,	28	4.81	–	–	–	–	29.48	16.96	24.82	–	–	–	–	–	–	6.25	2.57	–	–	44.25	–	2.60	1.41
Carbonate of potash,	1	26.88	–	–	–	–	–	–	18.48	–	–	–	–	–	–	–	–	19.52	–	–	–	–	.39
Phosphate of potash,	1	3.76	–	–	–	–	–	–	32.56	–	–	37.50	–	–	–	–	–	–	–	13.43	–	–	.92
Kainite,	5	3.18	–	–	–	–	16.48	12.51	13.56	–	–	–	–	–	–	18.97	1.15	9.80	–	20.25	–	33.25	2.13
Carnallite,	1	–	–	–	–	–	–	–	13.68	–	–	–	–	–	–	7.66	–	13.19	–	.56	–	41.56	–
Krugite,	1	4.82	–	–	–	–	–	–	8.42	–	–	–	–	–	–	5.27	12.45	8.79	–	31.94	–	6.63	14.96
Sulphate of magnesia (Kieserite),	9	22.70	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2.82	17.30	–	36.10	–	–	5.73
Nitrate of potash,	4	1.30	–	14.58	11.60	12.71	45.62	44.76	45.27	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Nitrate of soda,	37	1.38	–	16.22	14.28	15.04	–	–	–	–	–	–	–	–	–	35.50	–	–	–	–	–	.50	.50
Sulphate of ammonia,	28	1.06	–	21.68	19.59	22.03	–	–	–	–	–	–	–	–	–	–	–	–	–	60.00	–	–	–
Phosphate of ammonia,	1	6.05	–	–	–	10.37	–	–	–	–	–	43.86	–	–	–	–	–	–	–	12.46	–	–	.82
Sulphate of soda,	1	1.38	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	59.43	–	–	–
Saltpetre waste,	12	2.54	–	3.30	.52	2.22	30.94	1.55	13.66	–	–	–	–	–	–	37.04	.75	.19	–	1.85	–	46.25	–
Nitre salt-cake,	2	6.03	–	–	–	2.29	–	–	.87	–	–	–	–	–	–	29.56	–	–	–	47.77	–	–	3.92

Wood ashes,	527	10.38	-	-	-	-	10.80	1.20	5.39	5.58	.05	1.51	-	-	-	-	33.55	3.31	.96	-	-	-	16.28
Cotton-seed-hull ashes,	56	8.60	-	-	-	-	42.12	9.08	22.55	22.38	2.89	8.59	-	-	-	-	9.39	10.47	1.76	-	-	-	13.44
Ashes of spent tan-bark,	5	4.84	-	-	-	-	2.87	.60	1.81	2.77	.13	1.36	-	-	-	-	31.11	3.39	1.78	-	-	-	25.21
Corn-cob ashes,	1	1.20	-	-	-	-	-	-	7.08	-	-	2.37	-	-	-	-	11.70	-	1.28	-	-	-	52.09
Railroad-tie ashes,	1	4.70	-	-	-	-	-	-	.92	-	-	.56	-	-	-	-	2.51	-	-	-	-	-	80.20
Peat ashes,	1	4.67	-	-	-	-	-	-	.46	-	-	.11	-	-	-	-	2.28	1.63	6.13	-	-	-	45.17
Logwood ashes,	1	1.50	-	-	-	-	-	-	.08	-	-	2.30	-	-	-	-	3.90	-	-	-	-	-	9.70
Hard-pine wood ashes,	1	.75	-	-	-	-	-	-	10.16	-	-	2.24	-	-	-	-	24.95	-	-	-	-	-	29.90
Mill ashes,	1	.53	-	-	-	-	-	-	1.60	-	-	.46	-	-	-	-	34.93	1.35	-	-	-	-	36.36
Ashes from cremation of swill,	15	4.86	-	-	-	-	8.83	1.25	3.97	32.36	7.47	14.16	-	-	-	-	33.58	1.87	4.65	-	-	-	21.57
Ashes from blue works,	1	12.14	63.78	-	-	-	-	-	9.02	-	-	-	-	-	-	-	-	-	-	-	-	-	12.30
Sea-weed ashes,	1	1.47	-	-	-	-	-	-	.92	-	-	.30	-	-	-	8.76	6.06	4.37	-	2.98	-	6.60	63.65
Gypse,	1	1.64	-	-	-	-	-	-	-	-	-	-	-	-	-	-	50.87	-	-	-	-	-	2.87
Nova Scotia plaster (gypsum),	16	8.95	-	-	-	-	-	-	-	-	-	-	-	-	-	-	32.85	.75	-	44.87	-	-	3.47
Onondaga plaster (New York gypsum),	4	13.27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30.00	4.66	-	32.50	8.20	-	9.83
Lime,	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	93.63	-	-	-	-	-	1.33
Waste lime,	1	.80	-	-	-	-	-	-	-	-	-	-	-	-	-	-	74.12	-	-	-	-	-	.38
Gas-house lime,	3	22.28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	43.66	8.30	-	20.73	-	-	6.05
Lime waste from sugar factory,	1	36.30	-	-	-	-	-	-	.22	-	-	2.25	-	-	-	-	27.51	-	-	-	-	-	.32
Lime kiln ashes,	17	14.48	-	-	-	-	2.78	.02	1.28	3.16	.36	1.09	-	-	-	-	42.57	2.60	-	-	17.75	-	7.69
Bituminous coal ashes,	2	3.66	-	-	-	-	-	-	.38	-	-	.44	-	-	-	-	1.88	-	-	-	-	-	74.17
Carbonate of lime,	1	.47	-	-	-	-	-	-	-	-	-	-	-	-	-	-	52.98	-	-	-	-	-	-

	Analyses.	Moisture.	Ash.	NITROGEN.			POTASH.			TOTAL PHOSPHORIC ACID.			Soluble Phosphoric Acid.	Reverted Phosphoric Acid.	Insoluble Phosphoric Acid.	Soda.	Lime.	Magnesia.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
				Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.											
I. Chemicals, Refuse, Salts, Ashes, etc. — Concluded.																							
Marls (Massachusetts),	7	13.70	-	-	-	-	-	-	.24	2.72	.06	1.05	-	-	-	-	40.50	.64	.69	-	28.57	-	3.44
Marls (Virginia),	2	15.98	-	-	-	-	.61	.37	.49	.09	.08	.09	-	-	-	-	7.25	.21	-	.66	7.25	-	64.23
Green sand marl (Virginia),	1	1.25	-	-	-	-	-	-	1.14	-	-	9.37	-	-	-	-	25.78	-	5.13	-	-	-	41.32
Olive earth (Virginia),	1	1.97	-	-	-	-	-	-	.24	-	-	13.73	-	-	-	-	19.16	-	6.00	-	-	-	50.55
Ammoniated marl,	1	3.31	-	-	-	1.61	-	-	-	-	-	10.39	-	.41	9.98	-	-	-	-	-	-	-	-
Marl (North Carolina),	1	1.50	-	-	-	-	-	-	.04	-	-	.56	-	-	-	-	21.95	.61	-	-	-	-	50.18
Clay (so called),	1	.70	-	-	-	-	-	-	-	-	-	-	-	-	-	-	54.35	1.04	2.80	-	37.32	-	2.57
II. Guanos, Phosphates, etc.																							
Peruvian guano,	26	14.81	37.61	13.50	4.44	7.85	4.08	1.14	2.61	20.60	5.96	15.26	4.57	3.79	6.90	-	-	-	-	-	-	-	6.60
Bat guano from Texas,	9	40.09	18.24	10.51	2.58	6.47	-	-	1.31	6.53	1.00	3.76	-	-	-	-	-	-	-	-	-	-	2.00
Bat guano from Florida,	2	15.66	-	-	-	9.74	-	-	1.77	3.44	3.26	3.35	-	-	-	-	-	-	-	-	-	-	19.33
Rat guano from Florida,	1	10.32	-	-	-	3.32	-	-	6.85	-	-	2.30	-	-	-	-	-	-	-	-	-	-	1.15
Cuban guano,	5	24.27	-	2.74	.63	1.67	-	-	-	16.16	11.54	13.35	-	-	-	-	-	-	-	-	-	-	3.17
Caribbean guano (orchilla),	12	7.31	-	-	-	-	-	-	-	35.43	18.11	26.77	-	-	-	-	39.95	3.29	-	2.68	-	-	1.27
Mona Island guano,	1	13.32	-	-	-	.76	-	-	-	-	-	21.88	-	7.55	14.33	-	37.49	-	-	-	-	-	2.45

South Carolina rock phosphate,	7	1.36	-	-	-	-	-	-	-	30.51	24.70	27.42	.27	.07	27.13	-	41.87	3.03	4.80	-	-	-	9.04
South Carolina floats,	1	.83	-	-	-	-	-	-	-	-	-	23.39	-	2.33	21.06	-	-	-	-	-	-	-	20.16
Florida rock phosphate,	31	2.00	-	-	-	-	-	-	.21	38.97	6.95	26.02	-	1.47	19.70	-	30.40	-	7.68	-	2.08	-	27.29
Soft Florida phosphate,	3	4.87	-	-	-	-	-	-	-	19.94	17.71	18.73	-	-	-	-	23.72	-	6.82	-	-	-	20.92
Navassa phosphate,	2	7.60	-	-	-	-	-	-	-	34.45	34.09	34.27	-	-	-	-	37.45	-	10.27	-	-	-	2.70
Brockville phosphate,	1	2.50	-	-	-	-	-	-	-	-	-	35.21	-	-	-	-	-	-	-	-	-	-	6.46
Phosphatic slag,	4	1.45	-	-	-	-	-	-	-	30.51	18.91	23.49	-	3.06	21.65	-	48.66	3.42	10.12	-	-	-	9.40
Odorless phosphate,	6	2.99	-	-	-	-	.52	.04	.38	21.74	18.40	19.54	-	.52	19.82	-	51.42	-	-	-	2.51	-	9.14
Dissolved bone-black,	7	10.17	47.50	-	-	-	-	-	-	17.80	14.99	16.25	15.61	1.15	.37	-	-	-	-	-	-	-	3.99
Upton phosphate,	1	9.07	-	-	-	-	-	-	-	-	-	40.15	-	37.84	2.31	-	-	-	-	-	-	-	-
Bone-black,	5	4.60	-	-	-	-	-	-	-	30.54	16.56	28.28	-	-	-	-	-	-	-	-	-	-	3.64
Double superphosphate,	1	5.74	-	-	-	-	-	-	-	-	-	47.80	38.38	9.04	.38	-	16.00	-	-	1.19	-	-	.60
South American bone-ash,	1	7.00	-	-	-	-	-	-	-	-	-	35.89	-	-	-	-	44.89	-	-	-	-	-	4.50
Acid phosphate,	1	14.23	69.95	-	-	-	-	-	-	-	-	14.64	10.34	2.42	1.88	-	-	-	-	-	-	-	10.81
III. Refuse Substances.																							
Dried blood,	19	11.43	6.37	13.55	8.10	10.43	-	-	-	8.70	1.30	2.64	-	-	-	-	-	-	-	-	-	-	-
Ammonite,	1	5.88	-	-	-	11.33	-	-	-	-	-	3.43	-	-	-	-	-	-	-	-	-	-	1.38
Oleomargarine refuse,	1	8.54	14.42	-	-	12.12	-	-	-	-	-	.88	-	-	-	-	-	-	-	-	-	-	.96
Felt refuse,	1	29.24	33.53	-	-	5.26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sponge refuse,	1	7.25	-	-	-	2.43	-	-	-	-	-	3.19	-	-	-	-	3.94	1.27	-	-	-	-	39.05
Blood and bone,	2	8.36	-	6.80	6.68	6.74	-	-	-	11.39	10.62	11.01	-	2.82	7.80	-	-	-	-	-	-	-	-
Horn shavings,	1	4.83	-	-	-	15.31	-	-	-	-	-	.42	-	-	-	-	-	-	-	-	-	-	-

	Analyses.	Moisture.	Ash.	Nitrogen.			Potash.			Total Phosphoric Acid.			Soluble Phosphoric Acid.	Reverted Phosphoric Acid.	Insoluble Phosphoric Acid.	Soda.	Lime.	Magnesia.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
				Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.											
III. Refuse Substances — Continued.																							
Ivory dust,	1	11.50	52.63	–	–	6.64	–	–	–	–	–	24.56	.97	17.97	5.62	–	–	–	–	–	–	–	–
Horn and hoof waste,	3	10.17	7.63	15.49	11.84	13.25	–	–	–	2.30	1.36	1.83	–	–	–	–	–	–	–	–	–	–	.24
Raw wool,	1	6.95	7.54	–	–	12.88	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3.63
Wool waste,	11	11.77	24.10	10.20	.96	4.56	3.50	.06	1.68	.67	.05	.31	–	–	–	–	.11	.06	.80	–	–	–	8.20
Wool washings (water),	1	–	–	–	–	–	–	–	3.92	–	–	–	–	–	–	.49	.28	–	–	–	–	–	–
Wool washings (acid),	1	–	–	–	–	–	–	–	4.20	–	–	–	–	–	–	.40	.61	.20	–	–	–	–	–
Wool washings (alkaline),	1	92.03	3.28	–	–	.09	–	–	1.09	–	–	–	–	–	–	.92	.04	–	–	–	–	–	.22
Morocco factory waste,	1	22.72	–	–	–	1.16	–	–	.36	–	–	2.56	–	–	–	–	19.60	–	–	1.24	–	–	24.17
Meat scrap,	2	24.79	–	–	–	6.33	–	–	–	–	–	5.79	–	–	–	–	–	–	–	–	–	–	–
Meat mass,	5	12.09	13.60	11.50	9.69	10.44	–	–	–	3.58	.56	2.07	–	–	–	–	–	–	–	–	–	–	.58
Bone soup,	1	82.92	7.07	–	–	1.14	–	–	–	–	–	1.26	–	–	–	–	–	–	–	–	–	–	–
Dried soup from meat and bone,	1	14.80	8.40	–	–	9.97	–	–	–	–	–	.53	–	–	–	–	–	–	–	–	–	–	.64
Dried soup from rendering cattle feet,	1	10.80	7.50	–	–	14.47	–	–	–	–	–	.46	–	–	–	–	–	–	–	–	–	–	.26
Dried soup from horse rendering,	1	92.14	–	–	–	1.12	–	–	–	–	–	.14	–	–	–	–	–	–	–	–	–	–	–
Soap-grease refuse,	2	29.25	51.39	4.20	2.21	3.21	–	–	–	15.37	11.04	13.21	–	–	–	–	–	–	–	–	–	–	1.29
Bones,	170	6.76	53.03	4.70	1.57	3.87	–	–	–	32.52	15.16	22.43	.38	8.62	13.77	–	–	–	–	–	–	–	1.08

Meat and bone,	2	5.26	-	-	-	4.57	-	-	-	-	-	20.21	.26	7.03	13.05	-	-	-	-	-	-	-	1.22
Tankage,	19	8.20	-	9.16	2.66	6.14	-	-	-	24.30	1.72	12.84	-	4.06	7.46	-	-	-	-	-	-	-	-
Fish with less than twenty per cent. water,	73	12.18	21.50	11.40	5.97	7.58	-	-	-	15.91	5.50	8.48	.55	2.64	5.06	-	-	-	-	-	-	-	2.01
Fish with between twenty and forty per cent. water.	10	30.19	20.59	7.41	4.22	5.97	-	-	-	8.32	4.68	7.09	.74	2.69	3.64	-	-	-	-	-	-	-	1.68
Fish with more than forty per cent. water,	10	45.46	15.50	7.60	2.43	4.97	-	-	-	8.56	2.94	5.08	1.17	1.33	2.58	-	-	-	-	-	-	-	1.35
Whale meat, raw,	1	44.50	1.04	-	-	4.86	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lobster shells,	1	7.27	-	-	-	4.50	-	-	-	-	-	3.52	-	-	-	-	22.24	1.30	-	-	-	-	.27
Castor-bean pomace,	6	9.68	5.70	5.72	5.22	5.51	3.40	.64	1.57	2.26	1.57	2.18	-	-	-	-	.87	.29	-	-	-	-	1.75
Cotton-seed meal,	50	7.05	5.78	7.95	2.05	6.60	2.38	.48	1.76	3.36	.73	1.79	-	-	-	-	-	-	-	-	-	-	.28
Linseed meal,	2	8.43	-	-	-	6.34	-	-	1.25	-	-	1.84	-	-	-	-	-	-	-	-	-	-	-
Rotten brewers' grain,	1	78.77	-	-	-	.72	-	-	.04	-	-	.43	-	-	-	-	.26	.15	-	-	-	-	.59
Mill sweepings,	1	9.49	-	-	-	3.76	-	-	.66	-	-	1.18	-	-	-	-	-	-	-	-	-	-	5.01
Tobacco leaf,	1	13.05	21.01	-	-	2.75	-	-	7.24	-	-	.43	-	-	-	-	4.17	2.17	.32	-	-	-	4.17
Tobacco stems,	7	10.61	14.07	2.91	.90	2.30	10.60	3.76	7.03	2.09	.44	.62	-	-	-	.34	3.89	1.23	-	-	-	-	.82
Cotton waste, wet,	1	34.69	-	-	-	1.30	-	-	.80	-	-	1.54	-	-	-	-	2.45	1.13	-	-	-	-	41.33
Cotton waste, dry,	4	5.87	60.60	9.33	.96	1.77	1.76	.66	1.42	1.80	.26	.45	-	-	-	-	-	-	-	-	-	-	32.59
Refuse from calico works,	1	4.07	-	-	-	4.28	-	-	-	-	-	11.95	-	-	-	-	-	-	-	-	-	-	-
Cotton dust,	2	32.68	50.93	-	-	.78	-	-	.45	-	-	.32	-	-	-	-	-	-	-	-	-	-	42.22
Glucose refuse,	1	8.10	-	-	-	2.62	-	-	.15	-	-	.29	-	-	-	-	.18	.02	-	-	-	-	.07
Waste from lactate factory,	1	34.11	-	-	-	.68	-	-	-	-	-	.67	-	-	-	-	22.59	-	-	-	-	-	6.92
Hop refuse,	1	8.98	-	-	-	.98	-	-	.11	-	-	.20	-	-	-	-	.27	.10	-	-	-	-	.63
Banana skins,	1	13.99	-	-	-	.24	-	-	5.46	-	-	1.80	-	-	-	-	-	-	-	-	-	-	-

				Nitrogen.			Potash.			Total Phosphoric Acid.													
	Analyses.	Moisture.	Ash.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Soluble Phosphoric Acid.	Reverted Phosphoric Acid.	Insoluble Phosphoric Acid.	Soda.	Lime.	Magnesia.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
III. Refuse Substances — Concluded.																							
Tankage and blood,	1	14.43	-	-	-	5.88	-	-	-	-	-	6.84	5.44	1.08	.32	-	-	-	-	-	-	-	-
Sumac waste,	1	63.06	6.80	-	-	1.19	-	-	3.25	-	-	-	-	-	-	-	1.14	3.25	-	-	-	-	2.25
Eel grass,	2	35.39	15.60	.96	.70	.83	1.61	.21	.91	.41	.22	.32	-	-	-	1.63	2.13	.11	-	-	-	-	1.06
Pine-barren grass,	1	8.48	2.40	-	-	.16	-	-	.07	-	-	.18	-	-	-	-	-	-	-	-	-	-	1.67
Pine needles,	1	9.48	3.42	-	-	.46	-	-	.03	-	-	.12	-	-	-	-	-	-	-	-	-	-	1.22
Rockweed, green,	1	68.50	23.70	-	-	.62	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rockweed, dry,	1	10.68	35.75	-	-	1.45	-	-	4.89	-	-	2.75	-	-	-	7.90	7.66	.21	-	-	-	-	10.40
Jute waste,	1	13.10	-	-	-	1.50	-	-	.08	-	-	.72	-	-	-	-	-	-	-	-	-	-	-
Hair waste,	1	72.81	-	-	-	1.39	-	-	.32	-	-	.61	-	-	-	-	-	-	-	-	-	-	-
Starch waste from rubber factory,	1	10.01	.23	-	-	.02	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sludge from sewage precipitating tanks,	1	88.49	9.50	-	-	.05	-	-	.05	-	-	.10	-	-	-	-	1.58	.39	6.22	-	-	-	.93
Sludge,	1	6.28	-	-	-	.68	-	-	-	-	-	1.36	-	-	-	-	8.66	-	17.68	-	-	-	38.03
Residue from water filter,	1	94.22	-	-	-	.12	-	-	-	-	-	.05	-	-	-	-	-	-	-	-	-	-	-
Blue-green algæ (*Lyngbia majuscula*), dry,	1	16.26	-	-	-	4.25	-	-	.79	-	-	.19	-	-	-	3.53	2.06	1.18	-	-	-	-	5.53
Mussel mud, wet,	1	60.01	27.29	-	-	.21	-	-	6.17	-	-	.10	-	-	-	.70	.93	.14	3.48	-	-	-	-
Mussel mud, dry,	1	2.24	72.02	-	-	.72	-	-	-	-	-	.35	-	-	-	-	23.39	-	8.26	-	-	-	37.60

Madder,	2	11.93	-	-	-	.91	-	-	2.40	-	-	.35	-	-	-	-	3.93	.51	-	-	-	-	4.67
Salt mud,	2	53.37	41.19	.40	.39	.40	.33	.32	.33	-	-	-	-	-	-	.94	.91	.37	4.13	-	-	-	34.88
Fresh-water mud,	1	40.37	-	-	-	1.37	-	-	.22	-	-	.26	-	-	-	-	1.27	.29	1.80	-	-	-	18.26
Muck,	25	61.69	13.75	2.54	.12	.79	-	-	-	.17	.08	.13	-	-	-	-	-	-	-	-	-	-	10.68
Peat, wet,	11	61.36	7.66	1.40	.41	.85	-	-	.18	-	-	.09	-	-	-	-	.55	.72	2.14	-	-	-	2.14
Peat, dry,	2	14.67	17.26	-	-	1.89	-	-	.06	-	-	.03	-	-	-	-	-	-	-	-	-	-	10.14
Turf,	2	19.29	6.36	1.97	1.91	1.94	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Soot,	7	4.29	77.10	1.05	.09	.41	1.83	.21	.63	2.10	.19	1.13	-	-	-	-	2.99	1.19	6.38	-	-	-	66.06
IV. Animal Excrement, etc.																							
Barn-yard manure,	79	67.24	-	1.36	.21	.52	1.40	.13	.56	.75	.10	.39	-	-	-	-	.30	.19	-	-	-	-	8.00
Horse manure,	1	11.24	-	-	-	.74	-	-	2.82	-	-	1.46	-	-	-	-	-	-	-	-	-	-	12.60
Sheep manure,	4	29.22	-	-	-	1.44	-	-	1.17	-	-	.92	-	-	-	-	-	-	-	-	-	-	12.91
Drainage from a manure heap,	1	93.20	3.66	-	-	.98	-	-	.88	-	-	.24	-	-	-	-	-	-	-	-	-	-	-
Poudrette, dry,	1	5.25	35.45	-	-	3.58	-	-	.49	-	-	5.74	-	-	-	-	-	-	-	-	-	-	4.65
Goose manure,	1	48.92	-	-	-	.21	-	-	.81	-	-	.95	-	-	-	-	-	-	-	-	-	-	-
Hen manure, fresh,	2	52.35	24.75	1.20	.79	.99	.32	.18	.25	1.00	.47	.74	-	-	-	-	1.19	.89	-	1.24	-	-	23.50
Hen-house refuse,	2	7.37	-	-	-	.71	-	-	1.03	-	-	1.02	-	-	-	-	-	-	-	-	-	-	71.07

Average Per Cents. of Different Ingredients found in the Preceding Compilation of Analyses, calculated to Pounds per Ton of 2,000 Pounds.

	Moisture.	Ash.	Nitrogen.	Potash.	Total Phosphoric Acid.	Soda.	Lime.	Magnesia.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
I. Chemicals, Refuse, Salts, Ashes, etc.													
Muriate of potash,	35.	-	-	1,020.	-	134.	-	11.	-	-	-	976.	14.
Sulphate of potash (high grade),	37.	-	-	804.	-	89.	-	30.	-	914.	-	-	15.
Sulphate of potash-magnesia,	96.	-	-	496.	-	125.	51.	-	-	885.	-	52.	28.
Carbonate of potash,	538.	-	-	370.	-	-	-	390.	-	-	-*	-	8.
Phosphate of potash,	75.	-	-	651.	750.	-	-	-	-	269.	-	-	18.
Kainite,	64.	-	-	271.	-	379.	23.	196.	-	405.	-	665.	43.
Carnallite,	-	-	-	274.	-	153.	-	264.	-	11.	-	831.	-
Krugite,	96.	-	-	168.	-	105.	249.	176.	-	639.	-	133.	299.
Sulphate of magnesia (kieserite),	454.	-	-	-	-	-	56.	346.	-	722.	-	-	115.
Nitrate of potash,	26.	-	254.	905.	-	-	-	-	-	-	-	-	-
Nitrate of soda,	28.	-	301.	-	-	710.	-	-	-	-	-	10.	10.
Sulphate of ammonia,	212.	-	441.	-	-	-	-	-	-	1,200.	-	-	-
Phosphate of ammonia,	120.	-	207.	-	877.	-	-	-	-	249.	-	-	16.
Sulphate of soda,	28.	-	-	-	-	-	-	-	-	1,189.	-	-	-
Saltpetre waste,	51.	-	44.	273.2	-	740.8	15.	38.	-	37.	-	925.	-

Nitre salt-cake,	121.	-	56.	17.	-	591.	-	-	-	955.	-	-	78.
Wood ashes,	208.	-	-	108.	30.	-	671.	66.	19.	-	-	-	326.
Cotton-seed-hull ashes,	172.	-	-	451.	172.	-	188.	209.	35.	-	-	-	269.
Ashes of spent tan-bark,	97.	-	-	36.	37.	-	622.	68.	36.	-	-	-	504.
Corn-cob ashes,	24.	-	-	142.	47.	-	234.	-	26.	-	-	-	1,042.
Railroad-tie ashes,	94.	-	-	18.	11.	-	50.	-	-	-	-	-	1,604.
Peat ashes,	93.	-	-	9.	2.	-	46.	33.	123.	-	-	-	903.
Logwood ashes,	30.	-	-	2.	56.	-	78.	-	-	-	-	-	194.
Hard-pine wood ashes,	15.	-	-	203.	45.	-	499.	-	-	-	-	-	598.
Mill ashes,	11.	-	-	32.	9.	-	699.	27.	-	-	-	-	727.
Ashes from cremation of swill,	97.	-	-	79.	283.	-	672.	27.	93.	-	-	-	431.
Ashes from blue works,	243.	1,276.	-	180.	-	-	-	-	-	-	-	-	246.
Seaweed ashes,	29.	-	-	18.	6.	175.	121.	87.	-	60.	-	132.	1,273.
Gypse,	33.	-	-	-	-	-	1,017.	-	-	-	-	-	57.
Nova Scotia plaster (gypsum),	179.	-	-	-	-	-	657.	15.	-	897.	-	-	69.
Onondaga plaster (New York gypsum),	265.	-	-	-	-	-	606.	93.	-	650.	164.	-	187.
Lime (burnt),	-	-	-	-	-	-	1,973.	-	-	-	-	-	27.
Waste lime,	16.	-	-	-	-	-	1,482.	-	-	-	-	-	8.
Gas-house lime,	446.	-	-	-	-	-	873.	166.	-	415.	-	-	121.
Lime waste from sugar factory,	726.	-	-	4.	45.	-	550.	-	-	-	-	-	6.
Lime-kiln ashes,	290.	-	-	26.	22.	-	851.	52.	-	-	355.	-	154.
Bituminous coal ashes,	73.	-	-	8.	9.	-	38.	-	-	-	-	-	1,483.

* Not determined.

Average Per Cents. of Different Ingredients found in the Preceding Compilation of Analyses, calculated to Pounds per Ton of 2,000 Pounds — Continued.

	Moisture.	Ash.	Nitrogen.	Potash.	Total Phosphoric Acid.	Soda.	Lime.	Magnesia.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
I. *Chemicals, Refuse, Salts, Ashes, etc.* — Concluded.													
Carbonate of lime,	9.	-	-	-	-	-	1,060.	-	-	-	-	-	-
Marls (Massachusetts),	274.	-	-	5.	21.	-	810.	13.	14.	-	571.	-	69.
Marls (Virginia),	320.	-	-	10.	2.	-	145.	4.	-	13.	145.	-	1,285.
Green sand marls (Virginia),	25.	-	-	23.	187.	-	516.	-	103.	-	-	-	826.
Olive earth (Virginia),	39.	-	-	5.	275.	-	383.	-	120.	-	-	-	1,011.
Ammoniated marl,	66.	-	32.	-	208.	-	-	-	-	-	-	-	-
Marl (North Carolina),	30.	-	-	1.	11.	-	439.	12.	-	-	-	-	1,004.
II. *Guanos, Phosphates, etc.*													
Peruvian guano,	296.	752.	157.	52.	305.	-	-	-	-	-	-	-	132.
Bat guano from Texas,	802.	365.	129.	26.	75.	-	-	-	-	-	-	-	40.
Bat guano from Florida,	313.	-	195.	25.	67.	-	-	-	-	-	-	-	387.
Rat guano from Florida,	206.	-	66.	137.	46.	-	-	-	-	-	-	-	23.
Cuban guano,	485.	-	33.	-	267.	-	-	-	-	-	-	-	63.
Caribbean guano (orchilla),	146.	-	-	-	535.	-	799.	66.	-	54.	-	-	25.
Mona Island guano,	266.	-	15.	-	438.	-	750.	-	-	-	-	-	49.

South Carolina rock phosphate,	27.	-	-	-	549.	-	837.	61.	96.	-	-	-	181.
South Carolina floats,	17.	-	-	-	468.	-	-	-	-	-	-	-	403.
Florida rock phosphate,	40.	-	-	4.	520.	-	608.	-	154.	-	22.	-	546.
Soft Florida phosphate,	97.	-	-	-	375.	-	274.	-	136.	-	-	-	418.
Navassa phosphate,	152.	-	-	-	685.	-	749.	-	205.	-	-	-	54.
Brockville phosphate,	50.	-	-	-	704.	-	-	-	-	-	-	-	129.
Phosphatic slag,	29.	-	-	-	470.	-	973.	68.	202.	-	-	-	188.
Odorless phosphate,	60.	-	-	8.	391.	-	1,028.	-	-	-	50.	-	183.
Dissolved bone-black,	203.	950.	-	-	325.	-	-	-	-	-	-	-	80.
Upton phosphate,	181.	-	-	-	803.	-	-	-	-	-	-	-	-
Bone-black,	92.	-	-	-	565.	-	-	-	-	-	-	-	73.
Double superphosphate,	115.	-	-	-	956.	-	320.	-	-	24.	-	-	12.
South American bone ash,	140.	-	-	-	718.	-	898.	-	-	-	-	-	90.
Acid phosphate,	285.	1,399.	-	-	293.	-	-	-	-	-	-	-	216.
III. Refuse Substances.													
Dried blood,	229.	127.	209.	-	53.	-	-	-	-	-	-	-	-
Ammonite,	118.	-	227.	-	69.	-	-	-	-	-	-	-	28.
Oleomargarine refuse,	171.	288.	242.	-	18.	-	-	-	-	-	-	-	19.
Felt refuse,	585.	671.	105.	-	-	-	-	-	-	-	-	-	-
Sponge refuse,	145.	-	49.	-	64.	-	79.	25.	-	-	-	-	781.
Blood and bone,	167.	-	135.	-	220.	-	-	-	-	-	-	-	-
Horn shavings,	99.	-	306.	-	8.	-	-	-	-	-	-	-	-

Average Per Cents. of Different Ingredients found in the Preceding Compilation of Analyses, calculated to Pounds per Ton of 2,000 Pounds — Continued.

	Moisture.	Ash.	Nitrogen.	Potash.	Total Phosphoric Acid.	Soda.	Lime.	Magnesia.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
III. Refuse Substances — Continued.													
Ivory dust,	230.	1,053.	133.	-	491.	-	-	-	-	-	-	-	-
Horn and hoof waste,	203.	153.	265.	-	37.	-	-	-	-	-	-	-	5.
Raw wool,	139.	151.	258.	-	-	-	-	-	-	-	-	-	72.
Wool waste,	235.	582.	91.	34.	6.	-	2.	1.	16.	-	-	-	164.
Wool washings (water),	-	-	-	78.	-	10.	6.	-	-	-	-	-	-
Wool washings (acid),	-	-	-	84.	-	8.	12.	4.	-	-	-	-	-
Wool washings (alkaline),	1,841.	66.	2.	22.	-	18.	1.	-	-	-	-	-	4.
Morocco factory waste,	454.	-	23.	7.	51.	-	392.	-	-	25.	-	-	483.
Meat scrap,	496.	-	127.	-	116.	-	-	-	-	-	-	-	-
Meat mass,	242.	272.	209.	-	41.	-	-	-	-	-	-	-	12.
Bone soup,	1,658.	141.	23.	-	25.	-	-	-	-	-	-	-	-
Dried soup from meat and bone,	296.	168.	199.	-	11.	-	-	-	-	-	-	-	13.
Dried soup from rendering cattle feet,	216.	150.	289.	-	9.	-	-	-	-	-	-	-	5.
Dried soup from horse rendering,	1,843.	-	22.	-	3.	-	-	-	-	-	-	-	-
Soap-grease refuse,	585.	1,028.	64.	-	264.	-	-	-	-	-	-	-	26.

Ground bones,	135.	1,061.	77.	-	449.	-	-	-	-	-	-	-	22.
Meat and bone,	105.	-	91.	-	404.	-	-	-	-	-	-	-	24.
Tankage,	164.	-	123.	-	257.	-	-	-	-	-	-	-	-
Fish with less than twenty per cent. water,	244.	430.	152.	-	170.	-	-	-	-	-	-	-	40.
Fish with between twenty and forty per cent. water,	604.	412.	119.	-	142.	-	-	-	-	-	-	-	34.
Fish with more than forty per cent. water,	909.	310.	99.	-	102.	-	-	-	-	-	-	-	27.
Whale meat, raw,	890.	21.	96.	-	-	-	-	-	-	-	-	-	-
Lobster shells,	145.	-	90.	-	70.	-	445.	26.	-	-	-	-	5.
Castor-bean pomace,	194.	114.	110.	31.	44.	-	17.	6.	-	-	-	-	35.
Cotton-seed meal,	141.	116.	132.	35.	36.	-	-	-	-	-	-	-	6.
Linseed meal,	169.	-	127.	25.	37.	-	-	-	-	-	-	-	-
Rotten brewers' grain,	1,575.	-	15.	1.	17.	-	5.	3.	-	-	-	-	12.
Mill sweepings,	190.	-	75.	13.	24.	-	-	-	-	-	-	-	100.
Tobacco leaf,	261.	420.	55.	145.	9.	-	83.	43.	6.	-	-	-	83.
Tobacco stems,	212.	281.	46.	141.	12.	7.	78.	25.	-	-	-	-	16.
Cotton waste, wet,	694.	-	26.	16.	31.	-	49.	23.	-	-	-	-	827.
Cotton waste, dry,	117.	1,212.	35.	28.	9.	-	-	-	-	-	-	-	652.
Refuse from calico works,	81.	-	86.	-	239.	-	-	-	-	-	-	-	-
Cotton dust,	654.	1,019.	16.	9.	6.	-	-	-	-	-	-	-	844.
Glucose refuse,	162.	-	52.	3.	6.	-	4.	4.	-	-	-	-	1.
Waste from lactate factory,	682.	-	14.	-	13.	-	452.	-	-	-	-	-	138.
Hop refuse,	180.	-	20.	2.	4.	-	5.	2.	-	-	-	-	13.

Average Per Cents. of Different Ingredients found in the Preceding Compilation of Analyses, calculated to Pounds per Ton of 2,000 Pounds — Concluded.

	Moisture.	Ash.	Nitrogen.	Potash.	Total Phosphoric Acid.	Soda.	Lime.	Magnesia.	Ferric and Aluminic Oxides.	Sulphuric Acid.	Carbonic Acid.	Chlorine.	Insoluble Matter.
III. Refuse Substances — Concluded.													
Banana skins,	280.	-	5.	109.	36.	-	-	-	-	-	-	-	-
Tankage and blood,	289.	-	118.	-	137.	-	-	-	-	-	-	-	-
Sumac waste,	1,261.	136.	24.	65.	-	-	23.	65.	-	-	-	-	45.
Eel grass,	708.	312.	17.	18.	6.	33.	43.	2.	-	-	-	-	21.
Pine-barren grass,	170.	48.	3.	1.	4.	-	-	-	-	-	-	-	33.
Pine needles,	200.	68.	9.	1.	2.	-	-	-	-	-	-	-	24.
Rockweed, green,	1,370.	474.	12.	-	-	-	-	-	-	-	-	-	-
Rockweed, dry,	214.	715.	29.	98.	55.	158.	153.	4.	-	-	-	-	208.
Jute waste,	262.	-	3.	2.	14.	-	-	-	-	-	-	-	-
Hair waste,	1,456.	-	28.	6.	12.	-	-	-	-	-	-	-	-
Starch waste from rubber factory,	200.	5.	4.	-	-	-	-	-	-	-	-	-	-
Sludge from sewage precipitating tanks,	1,770.	190.	1.	1.	2.	-	32.	8.	124.	-	-	-	19.
Sludge,	126.	-	14.	-	27.	-	173.	-	354.	-	-	-	761.
Residue from water filter,	1,884.	-	2.	-	1.	-	-	-	-	-	-	-	-
Blue-green algæ (*Lyngbia majuscula*), dry,	325.	-	85.	16.	4.	71.	41.	24.	-	-	-	-	111.

Mussel mud, wet,	1,200.	546.	4.	123.	2.	14.	19.	3.	70.	-	-	-	-
Mussel mud, dry,	45.	1,440.	14.	-	7.	-	1,468.	165.	-	-	-	-	752.
Madder,	239.	-	18.	48.	7.	-	79.	10.	-	-	-	-	93.
Salt mud,	1,567.	824.	8.	7.	-	19.	18.	7.	83.	-	-	-	798.
Fresh-water mud,	807.	-	27.	4.	5.	-	25.	6.	36.	-	-	-	365.
Muck,	1,234.	275.	16.	-	3.	-	-	-	-	-	-	-	214.
Peat, wet,	1,227.	153.	17.	4.	2.	-	11.	14.	43.	-	-	-	43.
Peat, dry,	293.	345.	38.	1.	1.	-	-	-	-	-	-	-	203.
Turf,	386.	127.	39.	-	-	-	-	-	-	-	-	-	-
Soot,	86.	1,542.	8.	13.	23.	-	60.	24.	128.	-	-	-	1,321.
IV. Animal Excrement, etc.													
Barn-yard manure,	1,345.	-	10.	11.	8.	-	6.	4.	-	-	-	-	160.
Horse manure,	225.	-	15.	56.	29.	-	-	-	-	-	-	-	252.
Sheep manure,	584.	-	29.	23.	18.	-	-	-	-	-	-	-	258.
Drainage from manure heap,	1,864.	73.	20.	18.	5.	-	-	-	-	-	-	-	-
Poudrette, dry,	105.	709.	72.	10.	115.	-	-	-	-	-	-	-	93.
Goose manure,	978.	-	4.	16.	19.	-	-	-	-	-	-	-	-
Hen manure, fresh,	1,047.	49.	20.	5.	15.	-	24.	18.	-	25.	-	-	470.
Hen house refuse,	147.	-	14.	21.	20.	-	-	-	-	-	-	-	1,421.

5. Compilation of Analyses of Fruits, Garden Crops and Insecticides.

COMPILED BY H. D. HASKINS.

1. — Analyses of fruits.
2. — Analyses of garden crops.
3. — Relative proportions of phosphoric acid, potassium oxide and nitrogen in fruits and garden crops.
4. — Analyses of insecticides.

A computation of the results of a chemical analysis of twenty prominent garden crops shows the following average relative proportion of the three essential ingredients of plant food: —

	Parts.
Nitrogen,	2.2
Potassium oxide,	2.0
Phosphoric acid,	1.0

One thousand pounds of green garden vegetables contain, on the above-stated basis of relative proportion of essential constituents of plant food: —

	Pounds.
Nitrogen,	4.1
Potassium oxide,	3.9
Phosphoric acid,	1.9

The weight and particular stage of growth of the vegetables when harvested control, under otherwise corresponding conditions, the actual consumption of each of these articles of plant food. Our information regarding these points is still too fragmentary to enable a more detailed statement here beyond relative proportions. It must suffice for the present to call attention to the fact that a liberal manuring within reasonable limit pays, as a rule, better than a scanty one. — (C. A. Goessmann.)

1. *Analyses of Fruits.*

Fertilizing Constituents of Fruits.

[Average amounts in 1,000 parts of fresh or air-dry substance.]

	Moisture.	Nitrogen.	Ash.	Potassium Oxide.	Sodium Oxide.	Calcium Oxide.	Magnesium Oxide.	Phosphoric Acid.	Sulphuric Acid.	Chlorine.
Ericaceæ: —										
*Cranberries,	996	–	1.8	.9	.1	.3	.1	.3	–	–
*Cranberries,	894	.8	–	1.0	–	.2	.1	.3	–	–
Rosaceæ: —										
Apples,	831	.6	2.2	.8	.6	.1	.2	.3	.1	–
*Apples,	799	1.3	4.1	1.9	.3	.3	.3	.1	–	–
*Peaches,	884	–	3.4	2.5	–	.1	.2	.5	–	–
Pears,	831	.6	3.3	1.8	.3	.3	.2	.5	.2	–
Strawberries,	902	–	3.3	.7	.9	.5	–	.5	.1	.1
*Strawberries,	–	–	5.2	2.6	.2	.7	.4	1.0	–	–
*Strawberry vines,	–	–	33.4	3.5	4.5	12.2	1.3	4.8	–	–
Cherries,	825	–	3.9	2.0	.1	.3	.2	.6	.2	.1
Plums,	838	–	2.9	1.7	–	.3	.2	.4	.1	–
Saxifragaceæ: —										
*Currants, white,	–	–	5.9	3.1	.2	1.0	.3	1.1	–	–
*Currants, red,	871	–	4.1	1.9	.2	.8	.3	.9	–	–
Gooseberries,	903	–	3.3	1.3	.3	.4	.2	.7	–	–
Vitaceæ: —										
Grapes,	830	1.7	8.8	5.0	.1	1.0	.4	1.4	.5	.1
Grape seed,	110	19.0	22.7	6.9	.5	5.6	1.4	7.0	.8	.1

2. *Analyses of Garden Crops.*

Fertilizing Constituents of Garden Crops.

[Average amounts in 1,000 parts of fresh or air-dry substance.]

	Moisture.	Nitrogen.	Ash.	Potassium Oxide.	Sodium Oxide.	Calcium Oxide.	Magnesium Oxide.	Phosphoric Acid.	Sulphuric Acid.	Chlorine.
Chenopodiaceæ:—										
Mangolds,	880	1.8	9.1	4.8	1.5	.3	.4	.8	.3	.9
*Mangolds,	873	1.9	12.2	3.8	1.3	.6	.4	.9	–	–
Mangold leaves,	905	3.0	14.6	4.5	2.8	1.6	1.4	1.0	.8	2.3
Sugar beets,	805	1.6	7.1	3.8	.6	.4	.6	.9	.3	.3
*Sugar beets,	869	2.2	10.4	4.8	.8	.6	.4	1.0	.1	–
Sugar-beet tops,	840	2.0	9.6	2.8	2.3	.9	1.1	1.2	.2	.3
Sugar-beet leaves,	897	3.0	15.3	4.0	2.0	3.1	1.7	.7	.8	1.3
Sugar-beet seed,	146	–	45.3	11.1	4.2	10.2	7.3	7.5	2.0	1.9
*Red beets,	877	2.4	11.3	4.4	.9	.5	.3	.9	–	–
Spinach,	903	2.4	16.0	2.7	5.7	1.9	1.0	1.6	1.1	1.0
*Spinach,	922	3.4	9.6	9.6	2.1	.6	.5	.5	–	–
Compositeæ:—										
Lettuce, common,	940	–	8.1	3.7	.8	.5	.2	.7	.3	.4
Head lettuce,	943	2.2	10.3	3.9	.8	1.5	.6	1.0	.4	.8
*Head lettuce,	970	1.2	–	2.3	.2	.3	.1	.3	–	–
Roman lettuce,	925	2.0	9.8	2.5	3.5	1.2	.4	1.1	.4	.4
Artichoke,	811	–	10.1	2.4	.7	1.0	.4	3.9	.5	.2
*Artichoke, Jerusalem,	775	4.6	–	4.8	–	–	–	1.7	–	–
Convolvulaceæ:—										
Sweet potato,	758	2.4	7.4	3.7	.5	.7	.3	.8	.4	.9
Cruciferæ:—										
White turnips,	920	1.8	6.4	2.9	.6	.7	.2	.8	.7	.3
*White turnips,	895	1.8	10.1	3.9	.8	.9	.3	1.0	1.0	–
White turnip leaves,	898	3.0	11.9	2.8	1.1	3.9	.5	.9	1.1	1.2
*Ruta-bagas,	891	1.9	10.6	4.9	.7	.9	.3	1.2	–	–
Savoy cabbage,	871	5.3	14.0	3.9	1.4	3.0	.5	2.1	1.2	1.1
White cabbage,	900	3.0	9.6	4.3	.8	1.2	.4	1.1	1.3	.5
*White cabbage,	984	2.3	–	3.4	.3	.2	.1	.2	–	–
Cabbage leaves,	890	2.4	15.6	5.8	1.5	2.8	.6	1.4	2.4	1.3
Cauliflower,	904	4.0	8.0	3.6	.5	.5	.3	1.6	1.0	.3
Horse-radish,	767	4.3	19.7	7.7	.4	2.0	.4	2.0	4.9	.3

Fertilizing Constituents of Garden Crops — Continued.

[Average amounts in 1,000 parts of fresh or air-dry substance.]

	Moisture.	Nitrogen.	Ash.	Potassium Oxide.	Sodium Oxide.	Calcium Oxide.	Magnesium Oxide.	Phosphoric Acid.	Sulphuric Acid.	Chlorine.
Cruciferæ — Concluded.										
Radishes,	933	1.9	4.9	1.6	1.0	.7	.2	4.5	.3	.5
Kohlrabi,	850	4.8	12.3	4.3	.8	.4	.8	2.7	1.1	.6
Cucurbitaceæ: —										
Cucumbers,	956	1.6	5.8	2.4	.6	.4	.2	1.2	.4	.4
Pumpkins,	900	1.1	4.4	.9	.9	.3	.2	.7	.3	.4
Gramineæ: —										
Corn, whole plant, green,	829	1.9	10.4	3.7	.5	1.4	1.1	1.0	.3	.5
*Corn, whole plant, green,	786	4.1	-	3.8	.5	1.5	.9	1.5	-	-
Corn kernels,	144	16.0	12.4	3.7	.1	.3	1.9	5.7	.1	.2
*Corn kernels,	100	18.2	-	4.0	.3	.3	2.1	7.0	-	-
*Corn, whole ears,	90	14.1	-	4.7	.6	.2	1.8	5.7	-	-
*Corn stover,	282	11.2	37.4	13.2	7.9	5.2	2.6	3.0	-	-
Leguminosæ: —										
Hay of peas, cut green,	167	22.9	62.4	23.2	2.3	15.6	6.3	6.8	5.1	2.0
*Cow-pea (*Dolichos*), green,	788	2.9	-	3.1	.6	3.0	1.0	1.0	-	-
*Small pea (*Lathyrus sylvestris*), dry.	90	38.5	-	25.7	4.7	17.9	5.0	9.0	-	-
Peas (seed),	143	35.8	23.4	10.1	.2	1.1	1.9	8.4	.8	.4
Pea straw,	160	10.4	43.1	9.9	1.8	15.9	3.5	3.5	2.7	2.3
Garden beans (seed),	150	39.0	27.4	12.1	.4	1.5	2.1	9.7	1.1	.3
Bean straw,	166	-	40.2	12.8	3.2	11.1	2.5	3.9	1.7	3.1
Liliaceæ: —										
Asparagus,	933	3.2	5.0	1.2	.9	.6	.2	.9	.3	.3
Onions,	860	2.7	7.4	2.5	.2	1.6	.3	1.3	.4	.2
*Onions,	892	-	4.9	1.8	.1	.4	.2	.7	-	-
Solanaceæ: —										
Potatoes,	750	3.4	9.5	5.8	.3	.3	.5	1.6	.6	.3
*Potatoes,	798	2.1	9.9	2.9	.1	.1	.2	.7	-	-
Potato tops, nearly ripe,	770	4.9	19.7	4.3	.4	6.4	3.3	1.6	1.3	1.1
Potato tops, unripe,	825	6.3	16.5	4.4	.3	5.1	2.4	1.2	.8	.9
*Tomatoes,	940	1.7	-	3.6	-	.3	.2	.4	-	-
Tobacco leaves,	180	34.8	140.7	40.7	4.5	50.7	10.4	6.6	8.5	9.4
Tobacco stalks,	180	24.6	64.7	28.2	6.6	12.4	.5	9.2	2.2	2.4
*Tobacco stems,	106	22.9	140.7	64.6	3.4	38.9	12.3	6.0	-	-

Fertilizing Constituents of Garden Crops — Concluded.

[Average amounts in 1,000 parts of fresh or air-dry substance.]

	Moisture.	Nitrogen.	Ash.	Potassium Oxide.	Sodium Oxide.	Calcium Oxide.	Magnesium Oxide.	Phosphoric Acid.	Sulphuric Acid.	Chlorine.
Umbelliferæ: —										
Carrots, ...	850	2.2	8.2	3.0	1.7	.9	.4	1.1	.5	.4
*Carrots, ...	898	1.5	9.2	5.1	.6	.7	.2	.9	–	–
Carrot tops, ...	822	5.1	23.9	2.9	4.7	7.9	.8	1.0	1.8	2.4
Carrot tops, dry, . . .	98	31.3	125.2	48.8	40.3	20.9	6.7	6.1	–	–
Parsnips, ...	793	5.4	10.0	.4	.2	1.1	.6	1.9	.5	.4
*Parsnips, ...	803	2.2	–	6.2	.1	.9	.5	1.9	–	–
Celery, ...	841	2.4	17.6	7.6	–	2.3	1.0	2.2	1.0	2.8

Most of the foregoing analyses were compiled from the tables of E. Wolff. Those marked * are from analyses made at the Massachusetts State Agricultural Experiment Station, Amherst, Mass.

3. *Relative Proportions of Phosphoric Acid, Potassium Oxide and Nitrogen in Fruits.*

	Phosphoric Acid.	Potassium Oxide.	Nitrogen.
Ericaceæ: —			
*Cranberries, ...	1	3.0	–
*Cranberries, ...	1	3.4	2.6
Rosaceæ: —			
Apples, ...	1	2.7	2.0
*Apples, ...	1	1.9	1.3
*Peaches, ...	1	1.3	–
Pears, ...	1	3.6	1.2
Strawberries, ...	1	1.4	–
*Strawberries, ...	1	2.6	–
*Strawberry vines, . . .	1	.7	–
Cherries, ...	1	3.3	–
Plums, ...	1	4.3	–
Saxifragaceæ: —			
*Currants, white, ...	1	2.8	–
*Currants, red, ...	1	2.1	–
Gooseberries, ...	1	1.9	–
Vitaceæ: —			
Grapes, ...	1	3.6	1.2
Grape seed, ...	1	1.0	2.7

Relative Proportions of Phosphoric Acid, Potassium Oxide and Nitrogen in Garden Crops.

	Phosphoric Acid.	Potassium Oxide.	Nitrogen.
Chenopodiaceæ:—			
Mangolds,	1	6.0	2.3
*Mangolds,	1	4.2	2.1
Mangold leaves,	1	4.5	3.0
Sugar beets,	1	4.2	1.8
*Sugar beets,	1	4.8	2.2
Sugar-beet tops,	1	2.3	1.7
Sugar-beet leaves,	1	5.7	4.3
Sugar-beet seed,	1	1.5	–
*Red beets,	1	4.1	3.3
Spinach,	1	1.7	3.1
*Spinach,	1	19.2	6.8
Compositeæ:—			
Lettuce,	1	5.3	–
*Lettuce,	1	7.6	4.0
Head lettuce,	1	3.9	2.2
Roman lettuce,	1	2.3	1.8
*Jerusalem artichoke,	1	2.8	2.7
Convolvulaceæ:—			
Sweet potato,	1	4.6	3.0
Cruciferæ:—			
White turnips,	1	3.6	2.3
*White turnips,	1	3.9	1.8
White turnip leaves,	1	3.1	3.3
*Ruta-bagas,	1	4.1	1.6
Savoy cabbage,	1	1.9	2.5
White cabbage,	1	4.1	1.7
*White cabbage,	1	11.0	7.6
Cauliflower,	1	2.3	2.5
Horse-radish,	1	3.9	2.2
Radishes,	1	3.2	3.8
Kohlrabi,	1	1.6	1.8
Cucurbitaceæ:—			
Cucumbers,	1	2.0	1.3
Pumpkins,	1	.6	.7
Gramineæ:—			
Corn, whole plant, green,	1	3.7	1.9
*Corn, whole plant, green,	1	2.2	2.8
Corn kernels,	1	.6	2.8
*Corn kernels,	1	.6	2.6
*Corn, whole ears,	1	.8	2.5
*Corn stover,	1	4.4	3.7

Relative Proportions of Phosphoric Acid, Potassium Oxide and Nitrogen in Garden Crops — Concluded.

	Phosphoric Acid.	Potassium Oxide.	Nitrogen.
Leguminosæ: —			
Hay of peas, cut green, . .	1	3.4	3.4
*Cow-pea (*Dolichos*), ...	1	3.1	2.9
*Small pea (*Lathyrus sylvestris*),	1	3.4	4.2
Peas (seed),.	1	1.2	4.3
Pea straw, ...	1	2.8	4.0
Garden beans (seed), . . .	1	1.2	4.0
Bean straw, ...	1	3.3	–
Liliaceæ: —			
Asparagus, ...	1	1.3	3.6
Onions,.	1	1.9	2.1
*Onions,.	1	2.6	–
Solanaceæ: —			
Potatoes, ...	1	3.6	2.1
*Potatoes, ...	1	4.1	3.0
Potato tops, nearly ripe, . .	1	2.7	3.1
Potato tops, unripe, . . .	1	3.7	5.3
*Tomatoes, ...	1	8.7	4.5
Tobacco leaves, ...	1	6.2	5.3
Tobacco stalks, ...	1	3.1	2.7
Tobacco stems, ...	1	10.7	3.8
Umbelliferæ: —			
Carrots, ...	1	2.7	2.0
*Carrots, ...	1	5.7	1.7
Carrot tops, ...	1	2.9	5.1
*Carrot tops, dry, ...	1	8.0	5.1
Parsnips, ...	1	3.8	2.8
*Parsnips, ...	1	3.3	1.2
Celery,.	1	3.5	1.1

6. *Analyses of Insecticides.*

	Moisture.	Arsenious Oxide.	Copper Oxide.	Acetic Acid.	Nicotine.	Mercury.	Sulphur.	Sulphuric Acid.	Chlorine.	Calcium Oxide.	Potassium Oxide.	Ferric and Aluminic Oxides.	Matter Insoluble in Hydrochloric Acid.
Average of 12 analyses, ordinary Paris Green,	1.22	57.91	32.08	4.74	-	-	-	-	-	-	-	-	.20
Average of 4 analyses, "Lion Brand New-process Paris Green,"	4.64	54.91	7.93	-	-	-	-	6.65	-	15.76	.35	-	1.00
"Sulphatine,"	1.40	-	2.61	-	-	-	48.28	4.73	-	18.60	-	-	1.63
"Death to Rose Bugs,"	2.95	-	1.05	-	-	-	34.53	4.35	-	17.76	-	-	.49
"Professor De Graff's Carpet Bug Destroyer,"	95.81	-	-	-	-	.78	-	.48	.27	-	.26	.90	-
"Oriental Fertilizer and Bug Destroyer,"	87.14	2.38	-	-	-	-	-	.64	3.00	-	3.50	-	-
"Non-poisonous Potato Bug Destroyer,"	-	-	-	-	-	-	-	-	-	68.20	-	1.38	1.50
Tobacco liquor,	37.71	-	-	-	2.12	-	-	-	-	3.07	6.55	.23	-
Tobacco liquor,	40.89	-	-	-	.53	-	-	-	-	1.47	16.34	.01	-
Tobacco liquor,	-	-	-	-	4.55	-	-	-	-	-	-	-	-
Tobacco liquor,	-	-	-	-	4.82	-	-	-	-	-	-	-	-
"Nicotinia,"	10.00	-	-	-	-	-	-	-	-	4.45	9.15	-	2.12
Hellebore,	-	-	-	-	-	-	-	-	-	-	-	-	2.34
Hellebore,	-	-	-	-	-	-	-	-	-	-	-	-	38.12
"Peroxide of Silicate,"	1.65	.57	.33	-	-	-	-	49.66	-	41.18	-	-	2.31

As a rule, in all preceding analyses the essential constituents are determined and stated; blanks do not imply the absence of the non-essentials.

INDEX.

INDEX.

PAGE
Agriculturist, report of, 109
ANALYSES (TABLES):
  Agricultural chemicals, 326
  Animal excrements, 333
  Cattle feeds, 238
  Fertilizing ingredients in fodders, 251
  Fruits, 343
  Garden crops, 344
  Insecticides, 349
  Manurial substances, 329
Ankee grass, 141
Asparagus rust, 172
Aster, stem rot of, 161
Beans, effects of fertilizers on, 299
  Horse, 112, 138
  Soy, 109, 115
Begonia, leaf spot of, 168
Blackberry, late rust of, 174
Bordeaux mixture (dry), 153
Botanists, report of, 157
Bug death, 143
Bulletins (number and subject), 1887–97, 104
Cabbages, 109
  Soil tests with, 113
Carbohydrates of plants and seeds, 190
Chemist, report of (fertilizers), 271
Chemist, report of (foods), 188
Chrysanthemum rust, 176
Clovers, 111
  Alsike, 111, 129
  Common red, 129
  Crimson, 110, 111, 121, 128
  Mammoth, 111, 129
  Mixed forage crops *v.* clover, 284
  Sulphate *v.* muriate of potash for, 131
  Sweet, 110, 121, 136
Corn, 109
  Green manuring in culture of, 110, 120
  Hill *v.* drill culture, 110, 119
  Manure *v.* manure and potash as fertilizer, 116
  Soil tests with, 113
  Special fertilizer *v.* fertilizer richer in potash, 117
  Sweet, effects of fertilizers on, 300
Cucumber, leaf blight of, 171

PAGE

- Cystisus proliferus albus, 141
- Date, leaf spot of, 167
- DIGESTION EXPERIMENTS:
  - With ruminants, 258
  - With sheep, 235
  - With swine, 269
- Entomologist, report of, 185
- FEEDING EXPERIMENTS:
  - Cows (effect of narrow and wide rations), 200
  - Pigs (rice meal *v.* corn meal), 226
  - Pigs (oat feed *v.* corn meal), 231
  - Sheep, 235
  - Swine, 269
- FERTILIZERS:
  - Influence of, in garden crops, 295
  - New laws regulating trade in, 315
  - Official inspection of, 302
- FIELD EXPERIMENTS:
  - Effect of leguminous crops, 272
  - Influence of fertilizers on garden crops, 295
  - Mixed annual forage crops *v.* clovers, 284
  - Natural phosphates *v.* superphosphates, 290
  - Nitragin, 277
  - Observations with leguminous crops, 282
- Florida beggar weed, 141
- FODDER CROPS:
  - Ankee grass, 141
  - Cystisus proliferus albus, 141
  - Field peas, 138
  - Flat pea, 112, 136
  - Florida beggar weed, 141
  - Horse bean, 112, 138
  - Iris pabularia, 141
  - Oats, 139
  - Saccaline, 112, 140
  - Sorghum, 112, 140
  - Spurry, 141
- Forage crops, mixed, *v.* clovers, 284
- Fungiroid, 112, 143
- Galactan, distribution of, 192
- Grasses, 135
- GREEN MANURING IN CORN CULTURE:
  - Crimson clover, 110, 120
  - Sweet clover, 110, 120
  - White mustard, 110, 120
- Hay caps, 112, 145
- Horse bean, 112, 138
- Horticulturist, report of, 153
- India rubber plant, leaf spot on, 166
- Iris pabularia, 141
- Leaf spot (decorative plants), 162
- LEGUMINOUS CROPS:
  - Effect of, 272
  - Observations with, 282
- LETTUCE:
  - Drop of, 179
  - Top-burn of, 182

PAGE
Manure v. manure and potash for corn, ... 116
Maple leaves, wilt of, ... 181
Meteorologist, report of, ... 150
Millets, ... 111
  For fodder, ... 132
  For seed, ... 132
  Under false names, ... 142
  Variety tests, ... 133, 135
Nitragin, ... 277
OATS:
  Oats and vetch, ... 285
  Varieties of, ... 139
Onions, effects of fertilizers on, ... 298
Organization of station, ... 101
PEA:
  Field pea, ... 138
  Flat pea, ... 112, 136
Pentosans, phloroglucin method of estimation, ... 197
Phloroglucin method, ... 197
Phosphates v. superphosphates, ... 290
Phosphatic slag, ... 318
PIGS, FEEDING EXPERIMENTS WITH:
  Digestibility of feed stuffs, ... 269
  Oat feed v. corn meal, ... 231
  Rice meal v. corn meal, ... 226
Plant disease, nature of, ... 157
POTASH, MURIATE OF:
  Action on lime resources of the soil, ... 320
  Sulphate v. muriate for clover, ... 131
POTATOES:
  Scab of, ... 144
  Varieties of, ... 110, 121
POULTRY EXPERIMENTS:
  Composition of air-dry foods, ... 147
  Cut-bone v. animal meal for egg-production, ... 149
  Effect of condition powders on egg-production, ... 146, 148
RATIONS:
  Effect of narrow and wide, ... 200
Rose, black spot of, ... 170
Salt, action on lime resources of soil, ... 320
Seed testing, ... 155
Sheep, digestion experiments with, ... 235
Slag meal, ... 318
Soil tests, ... 112
  With cabbage, ... 113
  With corn, ... 113
  With soy beans, ... 115
  With Swedish turnips, ... 115
Sorghum, ... 140
Soy beans, ... 109
  Soil tests with, ... 115
Special corn fertilizer v. fertilizer richer in potash, ... 117
Spraying crops, ... 153
  Steam spraying outfit, ... 154
Spurry, ... 141
Strawberry, bacterial disease of, ... 159
Sulphate of iron as fertilizer, ... 142

PAGE
Sulphur in drill for scab, ... 112, 145
Swedish turnips, ... 109
  Soil tests with, ... 115
Symmes' hay caps, ... 112, 145
Tomatoes, effects of fertilizers on, ... 298
  Mildew of, ... 175
Treasurer, report of, ... 107
White mustard in green manuring for corn, ... 110, 120

PUBLIC DOCUMENT . . . . No. 31.

THIRTY-FIFTH ANNUAL REPORT

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE.

JANUARY, 1898.

BOSTON:
WRIGHT & POTTER PRINTING CO., STATE PRINTERS,
18 POST OFFICE SQUARE.
1898.

THIRTY-FIFTH ANNUAL REPORT

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE.

JANUARY, 1898.

BOSTON:
WRIGHT & POTTER PRINTING CO., STATE PRINTERS,
18 POST OFFICE SQUARE.
1898.

Commonwealth of Massachusetts.

MASSACHUSETTS AGRICULTURAL COLLEGE,
AMHERST, Jan. 1, 1898.

To His Excellency ROGER WOLCOTT.

SIR: — I have the honor to transmit herewith, to Your Excellency and the Honorable Council, the thirty-fifth annual report of the trustees of the Massachusetts Agricultural College.

I am, very respectfully,
Your obedient servant,

HENRY H. GOODELL,
President.

CONTENTS.

PAGE

Calendar, 7

Report of trustees, 9–23
  Courses of study, 9–14
  Deficiency of preparation, 15, 16
  Expenditure of State appropriations, 17
  Needs of the college, 19

Catalogue of officers and students, 26

Schedule of studies, 34
  Four-years course, 34
  Winter courses, 36
  Graduate courses, 38

Entrance examination papers, 1897, 42

Expenses, 47

Labor fund, 47

Rooms, 48

Scholarships, 48

Equipment, 49
  Agricultural department, 49
  Botanical department, 52
  Horticultural department, 53
  Zoölogical department, 55
  Veterinary department, 56
  Mathematical department, 57
  Chemical department, 58

Reports, 64
  Gifts, 65
  Treasurer to State, 67
  Treasurer to Secretary of Interior, 72
  Farm, 74
  Military department, 80

Appendix, 84
  Monograph on plume-moths, 85

Annual report of Hatch Experiment Station, 162
  Treasurer, 169
  Agriculturist, 171
  Meteorologist, 207
  Botanists, 209
  Horticulturist, 233
  Chemist (foods), 236
  Entomologist, 264
  Chemist (fertilizer), 268

CALENDAR FOR 1898–99.

1898.

January 5, Wednesday, winter term begins, at 8 A.M.

March 24, Thursday, winter term closes, at 10.15 A.M.

April 6, Wednesday, spring term begins, at 8 A.M.

June 18, Saturday, Grinnell prize examination of the senior class in agriculture.

June 19, Sunday,	Baccalaureate sermon. Address before the College Young Men's Christian Association.
June 20, Monday,	Burnham prize speaking. Meeting of the alumni. Flint prize oratorical contest.
June 21, Tuesday,	Class-day exercises. Military exercises. Reception by the president and trustees.

June 22, Wednesday, Commencement exercises.

June 23–24, Thursday and Friday, examinations for admission, at 9 A.M., Botanic Museum, Amherst; at Jacob Sleeper Hall, Boston University, 12 Somerset Street, Boston; and at Sedgwick Institute, Great Barrington. Two full days are required for examination, and candidates must come prepared to stay that length of time.

September 6–7, Tuesday and Wednesday, examinations for admission, at 9 A.M., Botanic Museum.

September 8, Thursday, fall term begins, at 8 A.M.

December 22, Thursday, fall term closes, at 10.15 A.M.

1899.

January 4, Wednesday, winter term begins, at 8 A.M.

March 23, Thursday, winter term closes, at 10.15 A.M.

ANNUAL REPORT OF THE TRUSTEES

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE.

His Excellency the Governor and the Honorable Council.

During the thirty years of its existence, the college, in common with all the other land-grant colleges, has passed through many vicissitudes. Heralded at first as the bright morning star, it soon lost popular favor, because it did not at once make itself felt in the agriculture of the State and transform the fields of dock and thistles into broad acres of waving grain. A season of depression ensued, followed again by one of buoyancy and hope, in which it made great strides. This in turn was succeeded by the financial troubles of the last few years, which it was the first to feel and from which it has been the last to recover. Reviewing the past, we cannot but feel that the stage of experiment is over, and we enter upon this the first year of its fourth decade with quickened hope that from a broader, surer foundation the college will continue to rise and fulfil its mission of providing that "liberal and practical education that shall fit the industrial classes for the several pursuits and professions in life." The requirements for entrance have been increased, the average rank has been raised, the courses strengthened and broadened and the faculty increased to meet the increased demands.

To carry out the purpose for which the college was founded, three separate courses have been established. First, to meet the requirements of those whose circumstances forbid a longer stay, a series of ten short winter courses, eleven weeks in length, but covering such practical instruction in agriculture and the allied sciences as will be most helpful to the farmer. For this examinations are not required, and neither degrees nor diplomas are conferred. Elective courses in botany, entomology, floriculture, fruit culture, market gardening and dairying have been thrown open to women, but it is unfortunate that lack of dormitory room practically excludes them from taking advantage of this instruction. Second, a four-years course, leading to the degree of Bachelor of Science. For the first three years a certain definite curriculum is required of all, while the studies of the fourth year, with the exception of English and military science, are entirely optional. Examinations must be passed for this course. Third, post-graduate courses, leading to the degrees of Master of Science and Doctor of Philosophy. Candidates for these degrees are required to choose one major and two minor studies from certain prescribed subjects.

The academic course of four years is divided between nine departments, with the following allotment of hours to the different studies: —

English language and literature,	533
Other languages,	507
Mathematics and drawing,	784
Chemistry and physics,	833
Botany,	519
Entomology, zoölogy and physiology,	559
Economic law and history,	381
Military science and practice,	496
Agricultural in general,	470
Horticulture,	377
Veterinary,	185
Geology and astronomy,	370
Total,	6,014

Briefly, the course in each department may be thus outlined: —

AGRICULTURE.

(*a*) The origin and formation of soils, their physical properties and how to improve them; (*b*) tillage, subsoiling, drainage and irrigation; (*c*) use of fertilizers and manures; (*d*) farm implements and plans of farm buildings; (*e*) animal husbandry, breeds, stock breeding and feeding. As aids to practical instruction, there are models of the domestic animals; a farm of four hundred acres; a barn with one hundred head of stock, types of the leading breeds, and a complete dairy outfit, where the operations of pasteurizing milk and cream, butter making, milk testing and separation of cream are carried on.

BOTANY.

(*a*) Structural and systematic botany; (*b*) economic botany; (*c*) study of the normal functions and diseases of plants; (*d*) plant physiology and its relation to agriculture. For practical work there is a laboratory abundantly supplied with microscopes, microtomes, histological reagents and numerous appliances for illustration and investigation of the phenomena of plant life.

CHEMISTRY.

The chemical department teaches the composition, the value and the uses of all products of nature and of art. This study is an essential part of the training of the farmer, the manufacturer, the business man, the physician and the advanced student of any subject, for it deals with the ultimate character of all kinds of matter.

The special fields of study are mineral and organic, the latter including vegetable and animal matter. Each of these is studied by analysis and synthesis both qualitative and quantitative. There are three laboratories to suit the varying wants of the students.

Chemical Instruction.

Domains.			*Methods.*	
Mineral.		Each studied by	Analysis,	qualitative. quantitative.
Organic,	vegetable. animal.		Synthesis,	qualitative. quantitative.

ENGLISH.

The aim of this department is to promote: (*a*) ability to give oral and written expression of thought in correct, effective English; (*b*) ability to present in logical form oral and written arguments on questions assigned for debate; (*c*) acquaintance with the masterpieces of English literature. This is secured by constant practice in writing and speaking, and by the study of American literature and rhetoric in freshman and sophomore years and English literature and logic in the junior and senior. Instruction is given partly by text-book and partly by lecture. The course in rhetoric consists of a study of the choice of words, the theory of phraseology, special objects in style, the sentence, the paragraph, the whole composition as regards plan, arrangement and parts. This is followed by a series of lectures on invention, taking up the different elements and underlying principles of literature. The work in American literature is partly by text-book and partly by lecture. The course in the last two years is carried on in the same thorough, practical way, debate taking the place of declamation.

HORTICULTURE.

Instruction is given in: (*a*) fruit culture; (*b*) market gardening; (*c*) floriculture; (*d*) forestry. For practical work there are extensive, well-stocked orchards, nurseries and greenhouses, where the production of fruit, market-garden and greenhouse crops is constantly carried on.

MATHEMATICS AND ENGINEERING.

(*a*) Pure mathematics; (*b*) physics; (*c*) drawing; (*d*) engineering. The department is well supplied with the necessary instruments for surveying and engineering, and practical work in the field is required. A laboratory for physics has recently been opened, where the student can solve for himself problems in mechanics, electricity, light and sound. The senior engineering option is designed to give to the student the necessary engineering training to enable him to take up and apply, on the lines of landscape engineering and the development of property, his knowlledge of landscape gardening, agriculture, forestry, botany and horticulture. It embraces a course of lectures, recitations and field work on the following subjects: topography, railroad curves, earth work, construction and maintenance of roads, water works and sewerage systems, etc.

MILITARY.

This was established by act of Congress, and all students, unless physically disabled, are required to attend its exercises. Its object is threefold: first, the dissemination of military knowledge throughout the country; second, physical exercise and muscular training; and third, to inculcate respect and obedience to those in authority. There are three hours' drill per week for the whole college, one hour recitation for the senior class and a weekly inspection of the rooms in the dormitory.

POLITICAL ECONOMY.

To make a good citizen and a successful man of business is the aim of this department. To realize this aim the course of instruction covers: (*a*) principles of political economy; (*b*) industrial history of England and America; (*c*) discussion of economic problems; (*d*) study of the science of government.

VETERINARY.

To give a general idea of the principles of veterinary science in such simple and comprehensive manner as to enable any person to give animals under his supervision the treatment that will tend to prevent the occurrence of disease among them, is the aim of the course of study in this department. (*a*) The hygiene of the stable; (*b*) the anatomy and physiology of the circulatory, respiratory and digestive systems; (*c*) a study of the common diseased processes and the causes, symptoms and effects of disease; (*d*) the nature, action and uses of different drugs. Skeletons of the domestic animals, specimens of diseased bone and tissue, and an Auzoux model of the horse form a part of the equipment. This study is elective.

ZOÖLOGY.

The work in this department commences with the study of human anatomy and physiology. It is followed by a course in zoölogy, taught by lectures and work in the laboratory. In the laboratory each student is required to dissect and study a series of typical animals, making drawings of the different organs. After this preparation the study of insects is taken up, — their classification and habits, and the various methods of destroying those that are injurious. In the senior year an elective course of more technical lectures is given, embracing such subjects as the anatomy, embryology, transformations, duration of life, color and diseases of insects, and the fertilization of plants by them. Each student is required to do original work and prepare a thesis before graduation. The whole is supplemented by a carefully arranged museum, containing, as far as possible, all the native animals of the Commonwealth, and by the extensive entomological collections of the professor in charge.

FACULTY.

The faculty number eighteen active resident members, one professor emeritus and one non-resident lecturer. The chair of mathematics and civil engineering made vacant by the resignation of Prof. Leonard Metcalf has been filled by the election of John E. Ostrander, C.E., late professor of civil engineering and mechanic arts in the College of Agriculture of the University of Idaho. Prof. William P. Brooks, after a year's absence spent in study abroad, has resumed his duties at the college. The mechanical and free-hand drawing heretofore conducted by the military officer will this year, as last, be taught by Mr. William H. Armstrong, a member of the junior class.

For a makeshift, until such time as a suitable building can be erected, the recitation room occupied by the president has been altered into a physical laboratory for the use of the junior class. Water and gas have been introduced, a small dynamo run by water motor has been installed, benches accommodating twenty to thirty workers fitted up, and the light regulated by shutters sliding up and down, operated by hydrostatic stop-cocks on the table.

It has been the policy to add each year, as opportunity presented or as there seemed demand, new studies to the optional courses. This year there is offered a course in general history, commencing with the Christian era, a course in geology and a course in astronomy.

The entering class was one-fourth larger this year than last, and there was a number of additions to higher classes. But the same deficiency in preparation still prevails. The applicants for admission represent nearly every county in the State. They come from the hills of Berkshire and the sands of the Cape, from the valley of the Connecticut and the shores of Massachusetts Bay. They are not farmers' sons alone, but come from the homes of mechanics, of nurserymen, of engineers, of those, in fact, who represent the "industrial classes," "to promote the liberal and practical education" of whom "in the several pursuits and professions in life" the Agricultural College was established. These applicants for admission are examined in the following subjects: arithmetic, algebra through quadratic equations, geometry (two books), English grammar and composition, descriptive geography, physical geography, United States history, civil government and physiology. To be successful in this examination an applicant must obtain a mark of 65 per cent. Of the last 247 applicants for admission, 54 failed in arithmetic at the first examination, 93 in algebra, 70 in geometry, 49 in English grammar, 41 in descriptive geography, 37 in physical geography, 39 in history, 38 in civil government and 41 in physiology. The largest number of failures have been in algebra, — $33\frac{1}{5}$ per cent.; the smallest number in physical geography, — 15 per cent.; while the average of failures in the nine subjects specified above is $26\frac{3}{4}$ per cent.

We have, then, an average of more than one-fourth of those who have presented themselves for admission to the college failing in the entrance examinations. It may be urged that too much importance should not be attached to failures in these tests; that examiners are often injudicious in the questions asked; that "Tom is always nervous at such times," and that "Henry can never do justice to himself on an examination." These and other similar excuses may be allowed, yet the deplorable fact remains that so many are "plucked" when the test comes.

As has been intimated, these candidates are fair representatives of the pupils in our public schools. Many are graduates of the high school, many more have had one or two years in the same. The fact of their failure must not, necessarily, be charged to the public school, for these same schools furnish many students who not only pass the entrance examination, but, after a four-years course, graduate with honor and success. The fault, or the limitation rather, is with the student himself or with those who should advise him. *The time devoted to preparation is too short.* A young man suddenly awakes to the idea that he wants to enter the Agricultural College. He fancies that, on the shaky foundation of a possible year in the high school, four or five weeks can build a preparation for college. *The time is too short.* Another, possessed of a similar idea, thinks that a few evenings of study, after the day's work is done, will enable him to "brush up" his mathematics. *The body is too tired.* He falls asleep over those difficult principles of geometry, and there is no time for that practical and repeated solution of problems by which alone the path of algebraic processes becomes familiar. The interests of successful work in any college require time and thoughtful study in the work of preparation.

That each year we are drawing into closer relationship with the agriculture of the State is apparent. The farmers are coming more and more to depend upon the college, and what is true now is just as surely going to increase in the future. In nothing does this more strikingly appear than in the matter of correspondence. During the last twelve months 5,528 letters have been answered in the experiment department alone. What does this mean? It means that at 5,528 points we have touched the interests of the agricultural life of this State. It means that 940 dairymen have wanted to know about butter fats, or the best-balanced ration, or the hundred other matters of vital interest. It means that 750 farmers have had questions to ask concerning fertilizers and fertilizer materials. It means that 316 intelligent men engaged in the practice of agriculture have wanted information respecting rotation of crops, millets and soya beans, or the effects of potash on the growth of corn. It means that 304 fruit growers have come and asked what were the best varieties of fruits, how to cultivate them and how to prevent disease. It means that 113 growers of flowers and vegetables under glass have been attacked by rusts, smuts or nematodes, and have lifted up the Macedonian cry, "Come over and help us." It means that 1,232 sufferers attacked by all kinds of winged, crawling, creeping foes have come to us for relief. It means that 103 good wives have seen the ruin of their household idols effected by the buffalo bug, and have cried out in their anguish, "What shall we do to be saved from these pests?" This is the work of only one department. In addition, there have been written from the office of administration during the same period over 7,000 letters on matters touching college interests.

Expenditure of State Appropriations.

The several amounts appropriated by the Legislature (chapter 15, Acts and Resolves of 1897) have nearly all been expended, and for the purposes indicated. The entire water system of the college has been replaced, furnishing ample protection from fire as well as an adequate amount for domestic supply. An emergency reservoir, with a capacity of 150,000 gallons, has been constructed on the highest point of the college grounds; 7,352 feet of six-inch and 2,172 feet of four-inch cast-iron pipe have been laid, with the necessary gates, hydrants and valves. The fire apparatus has been thoroughly overhauled, and 500 feet of Eureka, U. S., rubber-lined hose, two and five-eighths inches in diameter, with hose play pipes, hose connections and straps have been purchased. The whole work came within the appropriation, though it was found necessary to take down and reconstruct at a large additional expense the culvert through which the pipe was laid at the south end of the pond. It is safe to say that, but for the untiring efforts of Prof. Leonard Metcalf, the supervising engineer, who gave his time and his services without compensation, the college could not have successfully carried through this undertaking. It seems fitting, therefore, in this public manner to place on record our grateful recognition of the work he has done for the college. As a corollary to the change in our water system, we were enabled to place, at slight expense, water-closets and facilities for bathing in the north dormitory, — a much-needed improvement, whether viewed from the stand-point of comfort or sanitation.

The greenhouse for the investigation of plant diseases has been entirely remodelled, but the work is not quite completed. The laboratory for teaching botany has been enlarged to meet the requirements of changes in the course of study and consequent increase of students. It is now well lighted, well ventilated and commodious. The repairs on the two greenhouses have been practically completed and they are both in use.

ACCOMMODATIONS FOR THE SICK.

It may be proper to state that, through the generosity of the donor of Pratt Cottage, Mr. George D. Pratt of Long Island City, those of our students requiring care as the result of accident or sickness may enjoy the advantages of the hospital, on the payment of a fixed sum per diem, subject to the same rules and regulations as students of Amherst College. It is a great satisfaction to feel that in cases of serious illness our students can be removed from the college buildings and receive proper care.

THE MILITARY DEPARTMENT.

This department, required by act of Congress and accepted by the Commonwealth of Massachusetts, has received no particular encouragement, although its exhibition parades and drills form one of the most pleasing features of Commencement week. The War Department, as an incentive to good work, publishes each year in the "Army Register" the names of the three graduates in each college recommended by the president and commandant as having stood highest in the military department of the college.

One State, at least, has supplemented this by an act entitling each graduate of the Agricultural and Mechanical College of that State, who may be declared proficient by the United States army officer in charge, to a commission as brevet second lieutenant in the State militia. We would earnestly recommend petitioning the General Court for the passage of an act entitling the three graduates recommended each year for honorable mention in the "Army Register" to a commission as brevet second lieutenant in the Massachusetts State militia. It would be an incentive to the students themselves, and would offer an inducement to the youth of the State to enter an institution where excellent facilities are offered for military training.

Needs of the College.

Commissioner Harris never made a truer remark than when he said, "The laboratory is the pivot on which the Agricultural College is wheeling around to lead in this, the greatest of American education." But what he says of the college as a whole is equally applicable to every department. Instruction, without laboratory work to impress upon the mind the principles learned in the recitation room, is of little value. Precept and practice must go hand in hand, to make the exact scholar. Most of the departments are fairly well equipped for laboratory work. The veterinary is almost the sole exception, and in the present crowded state of the buildings it is impossible to find any adequate quarters. A single room, nine by fourteen feet, with one window, is all the space that can be allotted for practical work with the students in dissection or in the use of the microscope. For lack of other accommodations, the professor in charge is compelled to keep in the cellar of his own house animals on which he desires to experiment, or diseased subjects and carcasses that may be sent in for examination. The value of the domestic animals and their products in this country is something enormous, footing up to nearly two and one-half billions of dollars, distributed as follows: —

UNITED STATES STATISTICS.

Dairy Products for 1895 (Estimated).

PRODUCT.	Total Product.	Rate of Value.	Total Value.
Butter (pounds), . .	1,375,000,000	$0 20	$275,000,000
Cheese (pounds), . .	280,000,000	08	22,400,000
Milk (gallons), . .	1,750,000,000	09	157,500,000
Total, . . .	–	–	$454,900,000

Number of fowls, ...	383,000,000
Number of dozens of eggs produced, . . .	1,141,000,000
Value of both, ...	$343,000,000
Total value of farm animals, ...	$1,655,414,612
Total value of dairy products, ...	454,900,000
Total value of poultry and products, . . .	343,000,000
Total, ...	$2,453,314,612

In Massachusetts the latest figures give: —

MASSACHUSETTS STATISTICS.

1896.	Number.	Price.	Value.
Horses, ...	198,568	$64 67	$12,841,392 56
Cows, ...	174,167	30 78	5,360,860 26
Cattle other than cows, .	38,437	16 00	614,992 00
Sheep, ...	34,091	3 38	115,227 58
Swine, ...	40,570	8 44	342,410 80
Poultry, ...	553,970	–	246,703 00
Total, ...	–	–	$19,521,586 20

Value of Dairy Products.

1890.	Quantity.	Price.	Value.
Milk (gallons), . .	82,571,924	$0 09	$7,431,473 00
Butter (pounds), . .	10,410,300	20	2,082,060 00
Cheese (pounds), . .	385,533	08	30,842 00
Total, . . .	–	–	$9,544,375 00

Prices are from estimates of 1895, made to apply to products in United States. They should be higher for Massachusetts.

Value of farm animals, ...	$19,521,586 20
Value of dairy products, ...	9,544,375 00
Value of poultry products,*	553.970 00
Total, ...	$29,619,931 20

It is estimated that there is an annual loss of 6 per cent. on this valuation, resulting from disease, most of which is preventable. There is not, if I am informed correctly, a single place in this State where the prime object is the study of the diseases of the domestic animals. Other States have already recognized the importance of this subject, and provided means of instruction and study, for the two go hand in hand. Pennsylvania has appropriated $30,000 to the veterinary department of its university. Iowa has furnished the necessary buildings for its college. New York has granted $150,000 for buildings and $25,000 annually for running expenses. Ohio has appropriated large sums, but the exact figures have not been ascertained. In the ordinary business of life, where great capital is invested, the services of experts are sought. In this great industry, in which nearly thirty millions of capital are engaged, provision has not yet been made for the intelligent study of animal diseases, though nearly a million dollars' loss occurs annually through lack of knowledge. The natural place for the dissemination of such knowledge and for the study of the various plagues affecting our domestic animals is the veterinary department of the college, and for this two things are absolutely essential, — a laboratory and hospital-stable connected therewith, and a small annual appropriation for maintenance. The laboratory, with its recitation room, workshop and museum, is both educational and experimental. The stable, while it subserves both purposes, is more especially for investigation. It requires a larger outlay than at first thought may seem necessary. It must be built in a different manner from ordinary stables, to meet the exigencies of the case. Room should be provided for six stalls, each absolutely isolated from the others, cut off by a brick partition, the walls covered with adamant cement and the floors of artificial stone, so as to insure absolute disinfection at the close of each investigation. In this particular the bovine race is in no ways different from the human. Modern science would never think of introducing a patient suffering from typhoid fever into a small-pox or scarlet-fever ward. In like manner, germ-infected timber or earth would never do in stalls in which one week might be an aggravated case of cow-pox and the next one of tuberculosis. To provide for these buildings and their equipment we ask for $25,000 and an annual maintenance fund of $1,000.

---

* 2,769,850 dozen eggs, at 20 cents.

The chemical department requires for equipment and material the sum of $1,000 in order to place it in position to offer the educational facilities demanded. Charts, models, material, apparatus and chemicals are needed. With the changes made in the college curriculum, new wants have to be supplied. The senior electives, the post-graduate courses, the short winter courses call for instruction in almost every branch of theoretical and applied chemistry, and demonstrations in a wide range of subjects are made necessary. These include agricultural chemistry, physiological and medical chemistry, assaying, mineral analysis, metallurgy, gas analysis, sugar manufacturing, color chemistry and many other industrial processes. To answer these requirements there should be an abundance of material on hand for demonstration. In no other department is there so great and at the same time so unavoidable a consumption of material and using up of perishable equipment, most of which has to be imported. In almost every other college we find a certain definite sum, ranging from $700 to $1,000, annually appropriated to supply this waste. Lack of means has prevented such annual repair of loss, and at irregular intervals we are compelled to apply for aid.

Among the many unsolved problems confronting the dairyman is the effect of feed stuffs on the consistency and flavor of butter. Experiments in the past have been for the most part confined to the production of quantity. Dairymen are now calling for investigations of quality. Such work requires the erection and equipment of a small dairy building for purpose of experiment alone. A plant of this description would call for an outlay of $2,000 for the following special items: —

(*a*) A building 22 by 44 feet, with ice-house attached, 18 by 20 feet, including floor of artificial stone for creamery.

(*b*) Creamery fittings (boiler, engine, apparatus).

(*c*) Drainage.

(*d*) Heating building and connecting tanks.

In brief, then, the following amounts are asked for: —

Veterinary laboratory and equipment, ...	$25,000
Chemical equipment, ...	1,000
Dairy plant, ...	2,000
	$28,000

and an annual maintenance fund of $1,000, veterinary department.

In accordance with the act of Congress establishing these colleges, and requiring in their annual report the publication of matter of information to the people, an illustrated paper is appended by Prof. Charles H. Fernald on the plume-moths.

Respectfully submitted, by order of the trustees,

HENRY H. GOODELL,
President.

AMHERST, Jan. 1, 1898.

THE CORPORATION.

	Term expires.
WILLIAM H. BOWKER of BOSTON,	1899
J. D. W. FRENCH of BOSTON,	1899
J. HOWE DEMOND of NORTHAMPTON,	1900
ELMER D. HOWE of MARLBOROUGH,	1900
NATHANIEL I. BOWDITCH of FRAMINGHAM,	1901
WILLIAM WHEELER of CONCORD,	1901
ELIJAH W. WOOD of WEST NEWTON,	1902
CHARLES A. GLEASON of NEW BRAINTREE,	1902
JAMES DRAPER of WORCESTER,	1903
SAMUEL C. DAMON of LANCASTER,	1903
HENRY S. HYDE of SPRINGFIELD,	1904
MERRITT I. WHEELER of GREAT BARRINGTON,	1904
JAMES S. GRINNELL of GREENFIELD,	1905
CHARLES L. FLINT of BROOKLINE,	1905

Members Ex Officio.

HIS EXCELLENCY GOVERNOR ROGER WOLCOTT,
President of the Corporation.
HENRY H. GOODELL, *President of the College.*
FRANK A. HILL, *Secretary of the Board of Education.*
WILLIAM R. SESSIONS, *Secretary of the Board of Agriculture.*

JAMES S. GRINNELL of GREENFIELD,
Vice-President of the Corporation.

GEORGE F. MILLS of AMHERST, *Treasurer.*

CHARLES A. GLEASON of NEW BRAINTREE, *Auditor.*

Committee on Finance and Buildings.*

JAMES S. GRINNELL.

HENRY S. HYDE.

J. HOWE DEMOND.

SAMUEL C. DAMON.

CHARLES A. GLEASON, *Chairman.*

Committee on Course of Study and Faculty.*

WILLIAM H. BOWKER.

ELMER D. HOWE.

CHARLES L. FLINT.

J. D. W. FRENCH.

WILLIAM WHEELER, *Chairman.*

Committee on Farm and Horticultural Department.*

ELIJAH W. WOOD.

JAMES DRAPER.

NATHANIEL I. BOWDITCH.

MERRITT I. WHEELER.

WILLIAM R. SESSIONS, *Chairman.*

Committee on Experiment Department.*

CHARLES A. GLEASON.

ELIJAH W. WOOD.

WILLIAM WHEELER.

JAMES DRAPER.

WILLIAM R. SESSIONS, *Chairman.*

Board of Overseers.

STATE BOARD OF AGRICULTURE.

Examining Committee of Overseers.

GEORGE CRUICKSHANKS (*Ch'n*),	OF FITCHBURG.
E. A. HARWOOD, . . .	OF NORTH BROOKFIELD.
JOHN BURSLEY, . . .	OF WEST BARNSTABLE.
C. K. BREWSTER, . . .	OF WORTHINGTON.
WESLEY B. BARTON, . .	OF DALTON.

---

* The president of the college is ex officio a member of each of these committees.

The Faculty.

HENRY H. GOODELL, LL.D., *President*,
Professor of Modern Languages.

LEVI STOCKBRIDGE,
Professor of Agriculture, Honorary.

CHARLES A. GOESSMANN, Ph.D., LL.D.,
Professor of Chemistry.

SAMUEL T. MAYNARD, B.Sc.,
Professor of Horticulture.

CHARLES WELLINGTON, Ph.D.;
Associate Professor of Chemistry.

CHARLES H. FERNALD, Ph.D.,
Professor of Zoölogy.

Rev. CHARLES S. WALKER, Ph.D.,
Professor of Mental and Political Science.

WILLIAM P. BROOKS, Ph.D.,
Professor of Agriculture.

GEORGE F. MILLS, M.A.,
Professor of English and Latin.

JAMES B. PAIGE, D.V.S.,
Professor of Veterinary Science.

GEORGE E. STONE, Ph.D.,
Professor of Botany.

JOHN E. OSTRANDER, M.A., C.E.,
Professor of Mathematics and Civil Engineering.

HERMAN BABSON, M.A.,
Assistant Professor of English.

EDWARD R. FLINT, Ph.D.,
Assistant Professor of Chemistry.

FRED S. COOLEY, B.Sc.,
Assistant Professor of Agriculture.

RICHARD S. LULL, M.S.,
Assistant Professor of Zoölogy.

RALPH E. SMITH, B.Sc.,
Instructor in German and Botany.

PHILIP B. HASBROUCK, B.S.,
Assistant Professor of Mathematics.

WILLIAM M. WRIGHT, 1st Lieut., 2d Infantry, U.S.A.,
Professor of Military Science and Tactics.

ROBERT W. LYMAN, LL.D.,
Lecturer on Farm Law.

HENRY H. GOODELL, LL.D.,
Librarian.

Graduates of 1897.[*]

Master of Science.

Burgess, Albert Franklin,	Rockland.
Kinney, Asa Stephen,	Worcester.

Bachelor of Science.

Allen, Harry Francis (Boston Univ.),	Northborough.
Allen, John William (Boston Univ.),	Northborough.
Armstrong, Herbert Julius (Boston Univ.),	Sunderland.
Barry, John Marshall (Boston Univ.),	Boston.
Bartlett, James Lowell (Boston Univ.),	Salisbury.
Cheney, Liberty Lyon (Boston Univ.),	Southbridge.
Clark, Lafayette Franklin (Boston Univ.),	West Brattleboro, Vt.

---

[*] The annual report, being made in January, necessarily includes parts of two academic years, and the catalogue bears the names of such students as have been connected with the college during any portion of the year 1897.

Drew, George Albert (Boston Univ.),	Westford.	
Emrich, John Albert,	Amherst.	
Goessmann, Charles Ignatius (Boston Univ.),	Amherst.	
Leavens, George Davison (Boston Univ.),	Brooklyn Heights, N. Y.	
Norton, Charles Ayer (Boston Univ.),	Lynn.	
Palmer, Clayton Franklin (Boston Univ.),	Stockbridge.	
Peters, Charles Adams (Boston Univ.),	Worcester.	
Smith, Jr., Philip Henry (Boston Univ.),	South Hadley Falls.	
Howe, Edward Gardnier ('72),	Urbana, Ill.	
Stone, George Edward ('86),	Amherst.	
Total,		19

Senior Class.

Adjemian, Avedis Garrabet,	Kharpoot, Turkey.	
Baxter, Charles Newcomb,	Quincy.	
Clark, Clifford Gay,	Sunderland.	
Eaton, Julian Stiles,	Nyack, N. Y.	
Fisher, Willis Sikes,	Ludlow.	
Montgomery, Jr., Alexander,	Natick.	
Nickerson, John Peter,	West Harwich.	
Warden, Randall Duncan,	Roxbury.	
Wiley, Samuel William,	Amherst.	
Wright, George Henry,	Deerfield.	
Total,		10

Junior Class.

Armstrong, William Henry,	Cambridge.
Beaman, Dan Ashley,	Leverett.
Boutelle, Albert Arthur,	Leominster.
Canto, Ysidro Herrera,	Cansahcat, Yucatan.
Chapin, William Edward,	Chicopee.
Chapman, John Chauncey,	Amherst.

Courtney, Howard Scholes,	Attleborough.	
Dana, Herbert Warner,	South Amherst.	
Dutcher, John Remson,	Nyack, N. Y.	
Hinds, Warren Elmer,	Townsend.	
Hooker, William Anson,	Amherst.	
Hubbard, George Caleb,	Sunderland.	
Maynard, Howard Eddy,	Amherst.	
Pingree, Melvin Herbert,	Denmark, Me.	
Sharpe, Edward Hewett,	Northfield.	
Smith, Bernard Howard,	Middlefield.	
Smith, Carl William,	Melrose.	
Smith, Samuel Eldredge,	Middlefield.	
Stacy, Clifford Eli,	Gloucester.	
Turner, Frederick Harvey,	Housatonic.	
Walker, Charles Morehouse,	Amherst.	
Wright, Edwin Monroe,	Manteno, Ill.	
Total,		22

Sophomore Class.

Atkins, Edwin Kellogg,	North Amherst.
Baker, Howard,	Dudley.
Brown, Frank Howard,	Newton Centre.
Campbell, Morton Alfred,	Townsend.
Crane, Henry Lewis,	Ellis.
Crowell, Jr., Charles Augustus,	Everett.
Crowell, Warner Rogers,	Everett.
Felch, Percy Fletcher,	Worcester.
Frost, Arthur Forrester,	South Monmouth, Me.
Gile, Alfred Dewing,	Worcester.
Halligan, James Edward,	Roslindale.
Harmon, Arthur Atwell,	Chelmsford.
Hull, Edward Taylor,	Greenfield Hill, Conn.
Hunting, Nathan Justus,	Shutesbury.
Kellogg, James William,	Amherst.
Landers, Morris Bernard,	Bondsville.
Lewis, James,	Fairhaven.
March, Allen Lucas,	Ashfield.
Merrill, Frederic Augustus,	Boston.
Monahan, Arthur Coleman,	South Framingham.
Morrill, Austin Winfield,	Tewksbury.

Munson, Mark Hayes,	Huntington.
Otis, Wilbur Corthell,	Beachmont.
Ovalle Barros, Julio Moises,	Santiago, Chili.
Parmenter, George Freeman,	Dover.
Risley, Clayton Erastus,	Plainfield, N. J.
Rogers, William Berry,	Cambridge.
Saunders, Edward Boyle,	Southwick.
Stanley, Francis Guy,	Springfield.
Walker, Henry Earl,	Vineyard Haven.
West, Albert Merril,	Brookville.
Total,	31

Freshman Class.

Ahearn, Michael Francis,	Framingham.
Baker, John Brown,	Amherst.
Barry, John Cornelius,	Amherst.
Boutelle, Clarence Alfred,	Leominster.
Bridgeforth, George Ruffin,	Westmoreland, Ala.
Brooks, Percival Cushing,	Brockton.
Casey, Thomas,	Amherst.
Chickering, James Henry,	Dover.
Clarke, George Crowell,	Malden.
Cooke, Theodore Frederic,	Austerlitz, N. Y.
Curtis, Ernest Waldo,	Canton.
Dana, George Henry,	South Amherst.
Dawson, William Alucius,	Worcester.
Dickerman, William Carlton,	Taunton.
Dorman, Allison Rice,	Springfield.
Gamwell, Edward Stephen,	Pittsfield.
Gordon, Clarence Everett,	Clinton.
Graves, Jr., Thaddeus,	Hatfield.
Gurney, Victor Henry,	Forge Village.
Hemenway, Francis Ellis,	Williamsville.
Henry, James Buel,	Scitico, Conn.
Howard, John Herbert,	Littleton Common.
Jones, Clark Winthrop,	Huntington.
Jones, Cyrus Walter,	Amherst.
Judd, Warren Harold,	South Hadley Falls.
Leslie, Charles Thomas,	Pittsfield.
Macomber, Ernest Leslie,	Taunton.

Moulton, Harry Jackson,	Milford.	
Paul, Herbert Amasa,	Lynn.	
Rice, Charles Leslie,	Pittsfield.	
Root, Luther Augustus,	Deerfield.	
Smith, Ralph Ingram,	Leverett.	
Tashjian, Dickran Bedross,	Kharpoot, Turkey.	
Todd, John Harris,	Rowley.	
Wilson, Alexander Cavassa,	Boston.	
Total,		35

Graduates' Two-Years Course.

Ashley, Henry Simeon,	East Longmeadow.	
Burrington, John Cecil,	Charlemont.	
Colburn, Charles Day,	Westford.	
Dye, Willie Arius,	Sheffield.	
Humphrey, Charles Leonard,	Amherst.	
Merriman, Francis Evander,	Boston.	
Total,		6

Short Winter Courses.

Adams, Charles Moody,	Wayland.	
Charmbury, Thomas Herbert,	Amherst.	
Chiashi, Louie Yeizo,	Imadzumura, Japan.	
Doescher, John Fred,	Cherry Valley.	
Fiske, Charles Daniel,	Hampden.	
Fuller, Herman Kelso,	Lowell.	
Graham, Charles Sumner,	Westborough.	
Holt, Jonathan Edward,	Andover.	
Hopkins, Lemuel Truesdell,	Conway.	
Howes, Albert Lorenzo,	Ashfield.	
Leach, Oliver Herbert,	Florence.	
Moore, George Calvin,	Leverett.	
Pendleton, Charles Bemis,	Willimansett.	
Sherman, Wilbur Gifford,	Haverhill.	
Smith, Charles Atherton,	Buckland.	
Stowell, Herbert Willard,	Leverett.	
Total,		16

Graduate Course.

For Degree of M.S.

Armstrong (B.Sc., M. A. C., '97), Herbert Julius,	Sunderland.
Caudell (B.S., Oklahoma, '96), Andrew Nelson,	Kansas City, Mo.
Goessmann (B.Sc., M. A. C., '97), Charles Ignatius,	Amherst.
Hemenway (B.Sc., M. A. C., '95), Herbert Daniel,	Williamsville.
Kochi (B.S., Sapporo, '91), Chujiro,	Bingo, Japan.
Leavens (B.Sc., M. A. C., '97), George Davison,	Brooklyn Heights, N. Y.
Palmer (B.Sc., M. A. C., '97), Clayton Franklin,	Stockbridge.
Peters (B.Sc., M. A. C., '97), Charles Adams,	Worcester.
Stevens (B.A., Harvard Univ., '95), Waldo Warland,	Groton.

Total, ... 9

Resident Graduates at the College and Experiment Station.

Cooley, B.Sc., Robert Allen,	South Deerfield.
Drew, B.Sc., George Albert,	Westford.
Hammar, B.Sc., James Fabens,	Swampscott.
Haskins, B.Sc., Henri Darwin,	North Amherst.
Holland, B.Sc., Edward Bertram,	Amherst.
Holt, B.Sc., Jonathan Edward,	Andover.
Jones, B.Sc., Benjamin Kent,	Middlefield.
Kinney, B.Sc., Asa Stephen,	Worcester.
Putnam, B.Sc., Joseph Harry,	West Sutton.
Roper, B.Sc., Harry Howard,	East Hubbardston.
Smith, B.Sc., Frederic Jason,	North Hadley.
Smith, Jr., B.Sc., Philip Henry,	South Hadley Falls.
Smith, B.Sc., Robert Hyde,	Amherst.
Thomson, B.Sc., Henry Martin,	Monterey.
White, B.Sc., Edward Albert,	Ashby.

Total, ... 15

Special Students.

Cross (Amh. Coll.), Edward Winslow,	Manchester, N. H.	
Howard (Amh. Coll.), Arthur Day,	Glencoe, Ill.	
Kendall (Amh. Coll.), Henry Plimpton,	Walpole.	
Total,		3

Summary.

Graduate course: —		
For degree of M.S.,	9	
Four-years course: —		
Graduates of 1897,	19	
Senior class,	10	
Junior class,	22	
Sophomore class,	31	
Freshman class,	35	
Two-years course: —		
Graduates of 1897,	6	
Winter course,	16	
Resident graduates,	15	
Special students,	3	
Total,		166
Entered twice,		9
Total,		157

FOUR-YEARS COURSE OF STUDY.

FRESHMAN YEAR.

	Agriculture.	Botany and Horticulture.	Chemistry.	Natural History.	Mathematics.	Latin and English.	French and Social Science.	Drawing and Military.
Fall, . .	- - -	Botany, structural, —5.	- - -	- - -	Advanced algebra, — 5. Book-keeping,—2.	English, — 3.	French, — 4.	Study of tactics, — 1.
Winter, .	History of agriculture, soils and soil formation, — 4.	- - -	- - -	- - -	Advanced algebra and geometry (plane),— 4.	English, — 3.	French, — 4.	Mechanical drawing, — 6.
Summer, .	Soils: — characteristics, improvement of, drainage, etc., — 4.	Botany, analytical, — 4.	Lectures in elementary chemistry, — 3.	- - -	Geometry (solid), — 3.	English, — 3.	French, — 3.	- -

SOPHOMORE YEAR.

Fall, . .	Irrigation, disposition of sewage, manures and fertilizers, — 4.	Botany, economic, and laboratory work, — 4.	Lectures in elementary chemistry, — 4.	- - -	Trigonometry and surveying, — 5.	English, — 2.	- -	- -
Winter, .	- - -	Laboratory work, — 4.	Lectures and practice, — 4.	Anatomy and physiology,— 4.	Mechanics, — 2. Surveying, — 1.	English, — 3.	- -	- -
Summer, .	Relations of the atmosphere to plant-life, mowings, pastures, grasses, ensilage,—5.	Horticulture, — 5.	Dry and humid qualitative analysis, — 6.	- - -	Surveying, — 4.	English, — 2.	- -	- -

JUNIOR YEAR.

	Agriculture.	Botany and Horticulture.	Chemistry, Geology and Astronomy.	Zoölogy.	Mathematics.	Latin and English.	French and Social Science.	Drawing and Military.
Fall, . .	Field crops, seed raising, production and improvement of varieties, machines and implements, — 4.	Market gardening, — 3.	Qualitative analysis, — 5.	Zoölogy, laboratory work, — 8.	Physics, — 2.	English literature, — 4.	- -	- -
Winter, .	Breeds and breeding of live stock, poultry farming, — 2.	- - -	Lectures and practice in organic chemistry, — 6.	Zoölogy, — 3.	Physics, — 3. Laboratory physics, — 2.	English literature, — 4.	- -	- -
Summer, .	- - -	Landscape gardening, — 5.	The same continued, — 5.	Entomology, — 6.	Physics, — 4. Laboratory physics, — 2.	English, — 2.	- -	- -

SENIOR YEAR (ELECTIVE).*

Fall, . .	Dairy farming, — 5.	Botany, cryptogamic, — 8.	Chemical physics and quantitative analysis, — 8. Astronomy, — 5.	Entomology, — 8. Veterinary science, — 5.	Engineering, — 5. Analytical geometry, — 5.	English, — 2. Advanced English, — 5. Latin, — 5.	Political economy, — 5. German, — 5. History, — 5.	Military science, — 1.
Winter, .	Cattle feeding, — 5.	Botany, cryptogamic, — 8.	Advanced work with lectures, — 8. $\left.\begin{array}{l}\text{Astronomy,}\\\text{Geology,}\end{array}\right\}5.$	Entomology, — 8. Veterinary science, — 5.	Engineering, — 5. Differential calculus, — 5.	English, — 2. Advanced English, — 5. Latin, — 5.	Political economy, — 5. German, — 5. History, — 5.	Military science, — 1. Law lectures, — 1.
Summer, .	Experimental work in agriculture, — 5.	Botany, physiological, — 8.	The same continued, — 8. Geology, — 5.	Entomology, — 8. Veterinary science, — 5.	Engineering, — 5. Integral calculus, — 5.	English, — 2. Advanced English, — 5. Latin, — 5.	Constitutional history, — 5. German, — 5. History, — 5.	Military science, — 1.

---

* English and military science are required; of the other studies three at least must be chosen.

SHORT WINTER COURSES.

[All courses optional.]

AGRICULTURE.

	I. General Agriculture.	
1.	Soils and operations upon them, drainage, irrigation, etc.,	10
2.	Farm implements and machinery,	5
3.	Manures and fertilizers,	10
4.	Crops of the farm, characteristics, management, etc.,	10
5.	Crop rotation,	2
6.	Farm book-keeping,	5
7.	Agricultural economics,	11
8.	Farm, dairy and poultry management,	11
	Total hours,	64

	II. Animal Husbandry.	
1.	Introduction,	1
2.	Location and soil,	2
3.	Building,	4
4.	Breeds of cattle,*	10
5.	Breeds of horses,	6
6.	Grain and fodder crops,*	11
7.	Foods and feeding,*	11
8.	Extra,	19
	Total hours,	64

* With dairy course.

DAIRYING.

	III. Lectures and Class-room Work.	
1.	The soil and crops,	22
2.	The dairy breeds and cattle breeding,	22
3.	Stable construction and sanitation, care of cattle,	11
4.	Common diseases of stock, their prevention and treatment,	11
5.	Foods and feeding,	11
6.	Book-keeping for the dairy farm and butter factory,	22
7.	Pasteurization and preparation of milk on physicians' prescriptions,	11
	III. Lectures, etc. — Concluded.	
8.	Composition and physical peculiarities of milk; conditions which affect creaming, churning, methods of testing and preservation,	22
9.	Milk testing,	6
10.	Butter making,	12
11.	Practice in aeration, pasteurization,	6
	Total hours,	156

HORTICULTURE.

	IV. Fruit Culture.	
1.	Introduction,	1
2.	Propagation of fruit trees by seed, budding, grafting, forming the head, digging, planting, pruning, training, cultivation, etc.,	28
3.	Insects and fungous diseases,	3
	Total hours,	32

	V. Floriculture.	
1.	Greenhouse construction and heating,	6
2.	Propagation of greenhouse and other plants by seed, cuttings, grafting, etc.,	3
3.	Cultivation of rose, carnation, chrysanthemum and orchids,	12
4.	Propagation and care of greenhouse and bedding plants,	10
	V. Floriculture — Concluded.	
5.	Insects and fungi which attack greenhouse plants,	2
	Total hours,	33

	VI. Market Gardening.	
1.	Introduction, equipment, tools, manures, fertilizers, etc.,	3
2.	Greenhouse construction and heating,	6
3.	Forcing vegetables under glass,	3
4.	Seed growing by the market gardener,	3
5.	Special treatment required by each crop,	10
6.	Insects and fungi, with remedies,	2
	Total hours,	27

Botany.

VII. Lectures on Injurious Fungi of the Farm, Garden, Greenhouse, Orchard and Vineyard.

1.	Introduction,	2
2.	Nature and structure of rusts,	4
3.	Nature and structure of smuts,	4
4.	Nature and structure of mildews,	4
5.	Nature and structure of rots,	4
6.	Beneficial fungi of roots,	2
7.	Edible mushrooms,	2
	Total hours,	22

VIII. Lectures and Demonstrations on "How Plants Grow."

1.	Introduction,	1
2.	The parts of a plant,	1
3.	Structure of the cell and plant in general,	3
4.	Functions of root, stem and leaves,	3
5.	Food of plant obtained from air,	3
6.	Food of plant obtained from soil,	3
7.	Transference and elaboration of food,	2
8.	Growth of plants,	2
9.	Effects of light, moisture, heat and cold,	2
10.	Root tubercles on pea and clover,	1
11.	Cross fertilization of flowers,	1
	Total hours,	22

Chemistry.

IX. General Agricultural Chemistry.

1.	Introduction,	2
2.	The fourteen elements of agricultural chemistry,	1
3.	Rocks and soils,	8
4.	The atmosphere,	7
5.	The chemistry of crop-growing,	8
6.	Fertilizers,	8
7.	Animal chemistry,	8
	Total hours,	55

X. Chemistry of the Dairy.

1.	Introduction,	2
2.	The fourteen elements of agricultural chemistry,	14
3.	The physical properties of milk,	13
4.	Analysis of milk, butter, cheese and other dairy products,	13
5.	Chemistry of the manufacture of dairy products,	13
	Total hours,	55

Zoölogy.

XI. Animal Life on the Farm.

Total hours,	22

XII. Insect Friends and Foes of the Farmers.

Total hours,	33

GRADUATE COURSE.

1. Honorary degrees will not be conferred.

2. Applicants will not be eligible to the degree of M.S. until they have received the degree of B.Sc. or its equivalent.

3. The faculty shall offer a course of study in each of the following subjects: mathematics and physics; chemistry; agriculture; botany; horticulture; entomology; veterinary. Upon the satisfactory completion of any two of these the applicant shall receive the degree of M.S. This prescribed work may be done at the Massachusetts Agricultural College or at any institution which the applicant may choose; but in either case the degree shall be conferred only after the applicant has passed an examination at the college under such rules and regulations as may be prescribed.

4. The degree of Doctor of Philosophy may be conferred upon graduates of this college or other colleges of good standing who shall spend three years at this institution, taking chemistry, botany and entomology as their major and minor studies, if in this time the amount and quality of work done be satisfactory to the professors in charge of the above-named departments.

5. Every student in the graduate course shall pay twenty-five dollars to the treasurer of the college before receiving the degree of M.S. or Ph.D.

TEXT-BOOKS.

GRAY — "Manual." American Book Company, New York.

DARWIN and ACTON — "Practical Physiology of Plants." University Press, Cambridge.

STRASBURGER — "Practical Botany." Swan, Sonnenschein & Co., London.

SORAUER — "Physiology of Plants." Longmans, Green & Co., New York and London.

CAMPBELL — "Structural and Systematic Botany." Ginn & Co., Boston.

KNOBEL — "Trees and Shrubs of New England." Bradlee Whidden, Boston.

GREINER — "How to make the Garden pay." Wm. Maule, Philadelphia.

LONG — "Ornamental Gardening for Americans." Orange Judd Company, New York.

TAFT — "Greenhouse Construction" Orange Judd Company, New York.

WEED — "Insects and Insecticides." Orange Judd Company, New York.

WEED — "Fungi and Fungicides." Orange Judd Company, New York.

FULLER — "Practical Forestry." Orange Judd Company, New York.

MAYNARD — "Practical Fruit Grower." Orange Judd Company, New York.

MCALPINE — "How to know Grasses by their Leaves." David Douglas, Edinburgh.

LODEMAN — "The Spraying of Crops." Macmillan & Co., New York.

SAUNDERS — "Insects injurious to Fruits." Lippincott & Co., Philadelphia.

MORROW and HUNT — "Soils and Crops." Howard & Wilson Publishing Company.

AIKMAN — "Manures and the Principles of Manuring." Wm. Blackwood & Son, Edinburgh.

MILES — "Stock Breeding" D Appleton & Co., New York.

CURTIS — "Horses, Cattle, Sheep and Swine." Orange Judd Company, New York.

FARRINGTON and WOLL — "Testing Milk and its Products" Mendota Book Company, Madison, Wis.

VON RICHTER — "A Text-book of Inorganic Chemistry." P. Blakiston, Son & Co., Philadelphia.

MÜTER — "Analytical Chemistry." P. Blakiston, Son & Co., Philadelphia.

ROSCOE — "Lessons in Elementary Chemistry." Macmillan & Co., New York.

BERNTHSEN and MCGOWAN — "Text-book of Organic Chemistry" Blackie & Son, London.

REYNOLDS — "Experimental Chemistry" Longmans, Green & Co., New York and London.

SUTTON — "Volumetric Analysis." J. & A. Churchill, London.

DANA — "Manual of Determinative Mineralogy." John Wiley & Sons, New York.

DANA — "A Text-book of Elementary Mechanics for the Use of Colleges and Schools." John Wiley & Sons, New York.

GAGE — "The Principles of Physics." Ginn & Co., Boston.

FAUNCE — "Mechanical Drawing." Linus Faunce, Boston

WELLS — "College Algebra." Leach, Shewell & Sanborn, Boston.

MESERVEY — "Meservey's Book-keeping, Single and Double Entry." Thompson, Brown & Co., Boston.

WELLS — "Plane and Solid Geometry." Leach, Shewell & Sanborn, Boston.

WELLS — "Essentials of Trigonometry." Leach, Shewell & Sanborn, Boston

GILLESPIE — "A Manual on the Principles and Practice of Road Making." A. S. Barnes & Co., New York.

Merriman — "A Treatise on Hydraulics." John Wiley & Sons, New York.

Miller — "A Treatise on Plane and Spherical Trigonometry." Leach, Shewell & Sanborn, Boston.

Raymond — "A Text-book on Plane Surveying." American Book Company, New York.

Faunce — "Descriptive Geometry." Ginn & Co., Boston.

Merriman — "Text-book on Least Squares." John Wiley & Sons, New York.

Martin — "The Human Body" (briefer course). Henry Holt & Co., New York.

Walker — "Political Economy" (briefer course). Henry Holt & Co., New York.

Walker — "The Industrial History of England." Methuen & Co., London.

Wilson — "The State." D. C. Heath, Boston.

Gibbins — "A Short Constitutional History of England" Ginn & Co., Boston.

Genung — "Outlines of Rhetoric." Ginn & Co., Boston.

Wentworth — "Irving's Sketch Book." Allyn & Bacon, Boston.

Longfellow — "Poems." Houghton, Mifflin & Co , Boston.

Pattee — "A History of American Literature." Silver, Burdett & Co., Boston.

Pancoast — "Representative English Literature." Henry Holt & Co., New York.

Jevons — "Logic." Science Primer Series. American Book Company, New York.

Corson — "Selections from Chaucer's Canterbury Tales." The Macmillan Company, New York.

Rolfe — "English Classics." Harper & Brothers, New York.

Whitney — "French Grammar." Henry Holt & Co., New York.

Whitney — "German Grammar." Henry Holt & Co., New York.

Sheldon — "Short German Grammar." D. C. Heath & Co., Boston.

Hodges — "Course in Scientific German." D C. Heath & Co., Boston.

Pettit — "Elements of Military Science." The Tuttle, Morehouse & Taylor Press, New Haven, Conn.

"Infantry Drill Regulations." Army and Navy Journal, New York.

To give not only a practical but a liberal education is the aim in each department, and the several courses have been so arranged as to best subserve that end. Exercises in composition and declamation are held throughout the course. The instruction in agriculture and horticulture is both theoretical and practical, the lessons of the recitation room being practically enforced in the garden and field. Students are allowed to work for wages during such leisure hours as are at their disposal. Under the act by which the college was founded, instruction in military tactics is imperative, and each student, unless physically debarred,* is required to attend such exercises as are prescribed, under the direction of a regular army officer stationed at the college.

FOUR-YEARS COURSE.

Admission.

Candidates for admission to the freshman class will be examined orally and in writing upon the following subjects: English grammar, geography, United States history, physiology, physical geography, arithmetic, the metric system, algebra (through quadratics), geometry (two books) and civil government (Mowry's "Studies in Civil Government"). The standard required is 65 per cent. on each paper. Diplomas from high schools will *not* be received in place of examination. Examinations in the following subjects may be taken a year before the candidate expects to enter college: English grammar, geography, United States history, physical geography and physiology. Satisfactory examination in a substantial part of the subjects offered will be required, that the applicant may have credit for this preliminary examination.

Candidates for higher standing are examined as above, and also in the studies gone over by the class to which they desire admission.

No one can be admitted to the college until he is sixteen years of age. The regular examinations for admission are held at the Botanic Museum, at 9 o'clock A.M., on Thursday and Friday, June 23 and 24, and on Tuesday and Wednesday, September 6 and 7; but candidates may be examined and admitted at any other time in the year. For the accommodation of those living in the eastern part of the State, examinations will also be held at 9 o'clock A.M., on Thursday and Friday, June 23 and 24, at Jacob Sleeper Hall, Boston University, 12 Somerset Street, Boston; and for the accommodation of those in the western part of the State, at the same date and time, at the Sedgwick Institute, Great Barrington, by James Bird. Two full days are required for examination, and candidates must come prepared to stay that length of time.

---

* Certificates of disability must be procured of Dr. Herbert B. Perry of Amherst.

WINTER COURSES.

For these short winter courses examinations are not required. They commence the first Wednesday in January and end the third Wednesday in March. Candidates must be at least sixteen years of age. The doors of the college are opened to applicants from both sexes. The same privileges in regard to room and board will obtain as with other students. Attendance upon general exercises is required. The usual fees for apparatus and material used in laboratory work will be required. Attendance upon military drill is not expected.

ENTRANCE EXAMINATION PAPERS USED IN 1897.

The standard required is 65 per cent. on each paper.

Arithmetic and Metric System.

1. Divide the least common multiple of 7, 42, 6, 9, 10 and 630 by the greatest common divisor of 110, 140 and 680.

2. $\frac{\frac{1}{2} \text{ of } 7\frac{1}{2}}{\frac{3}{8} \text{ of } 15} + \frac{4\frac{3}{4} \times \frac{9}{10}}{11 \times 1\frac{1}{2}} = ?$ Give answer in lowest terms.

3. A speculator bought 48 bales of cotton, and afterward sold the whole for $2,008.80, losing 7%. What was the cost of each bale?

4. What must be the face of a note at 10 months, interest at 8%, so that the proceeds may be $448.00?

5. $(2.8)^3 \div \sqrt{.117649} = ?$

6. What will be the weight in grams of the water contained in a rectangular vessel 2 m. × 9 cm. × 7 dm.?

7. How many pails of water are there in a tank 10 m. 4 cm. long, 6 m. 2 dm. wide and 9 dm. 4 cm. deep, if the capacity of the pail is 5 litres?

Algebra.

Resolve into prime factors —

1. (a) $(5x+8y)^2-(4x-3y)^2$.
   (b) $(2x+3y)(3x)-(2x+3y)(2y)$.
   (c) (x^2-7x+6).

2. A cistern could be filled with water by means of one pipe alone in six hours and by means of another pipe alone in eight hours, and it could be emptied by a tap in twelve hours if the two pipes were closed. In what time will the cistern be filled if the pipes and tap are all open?

3. $$\left.\begin{array}{l}\dfrac{12}{x}+\dfrac{8}{y}=8\\[2ex]\dfrac{27}{x}-\dfrac{12}{y}=3\end{array}\right\}\text{ solve for } x \text{ and } y.$$

4. Find the square root of

$$9x+10-12x^{\frac{1}{2}}-4x^{-\frac{1}{2}}+x^{-1}.$$

5. Rationalize the denominator of

$$\frac{25\sqrt{3}-4\sqrt{2}}{7\sqrt{3}-5\sqrt{2}}$$

6. Divide $a^{\frac{2}{3}}+b^{\frac{2}{3}}-c^{\frac{2}{3}}+2a^{\frac{1}{3}}\,b^{\frac{1}{3}}$ by $a^{\frac{1}{3}}+b^{\frac{1}{3}}+c^{\frac{1}{3}}$.

7. $$\left.\begin{array}{l}x^2-2xy=5\\x^2+y^2=29\end{array}\right\}\text{ solve for } x \text{ and } y.$$

GEOMETRY.

1. Each side of an equilateral triangle is two feet; find its altitude.

Prove the following: —

2. The line joining the middle points of two sides of a triangle is parallel to the third side and equal to one-half of it.

3. The perpendiculars at the middle points of the sides of a triangle meet in a common point.

4. In the same circle, or equal circles, two central angles are in the same ratio as the intercepted arcs. Give proof when the arcs are incommensurable.

5. An inscribed angle is measured by one-half its intercepted arc. Give proof when one side of the angle is a diameter.

UNITED STATES HISTORY.

NOTE. — Penmanship, spelling, capitalization and punctuation will be considered in determining the excellence of your paper.

1. Contrast the settlement of the Virginia colony at Jamestown and that of the Massachusetts colony at Plymouth. Give dates of each settlement.

2. (*a*) Name the thirteen original States. (*b*) What were the "Articles of Confederation," and what were their weak points? (*c*) When was the Constitution adopted?

3. The causes, principal events and outcome of the French and Indian War.

4. Give brief accounts of the following: (*a*) The Stamp Act. (*b*) The Boston Massacre. (*c*) The Boston Tea Party.

5. Write a short account of the administration of Andrew Jackson.

6. For what were the following men noted in the *legislative* history of our country: (*a*) Benjamin Franklin, (*b*) Patrick Henry, (*c*) John Jay, (*d*) Alexander Hamilton, (*e*) James Monroe, (*f*) Daniel Webster, (*g*) John C. Calhoun, (*h*) Abraham Lincoln, (*i*) Charles Sumner, (*j*) Grover Cleveland?

7–8. The Missouri Compromise. Give the cause, purport of and effect.

9. A few words on the following engagements of the Civil War: (*a*) Farragut's attack on New Orleans. (*b*) The battle of Gettysburg.

10. Name the Presidents that were elected for two terms.

GEOGRAPHY.

NOTE. — Penmanship, spelling, capitalization and punctuation will be considered in determining the excellence of your paper.

1. Draw a line from Boston to New Orleans. Through what States would the line pass?

2. Bound the United States of America.

3–4. A careful and comprehensive account of Mexico.

5. Locate: Corea, Amsterdam, Wales, Provincetown, Warsaw, Poland, Calcutta, Sydney, Queenstown, Valparaiso.

6. Describe a journey eastward, by water, from Chicago to Constantinople.

7–8. The East Indies: (*a*) names of the principal islands; (*b*) geographical features; (*c*) people; (*d*) resources and products.

9. Name six republics on the earth.

10. The States bordering upon the Gulf of Mexico, and their capitals.

PHYSICAL GEOGRAPHY.

NOTE. — Penmanship, spelling, capitalization and punctuation will be considered in determining the excellence of your paper.

1. What are the tides? Where are they greatest, and where least? What causes them? Tell the difference between flood and high tides.

2. What is the Sargasso Sea? What causes it?

3. Name and describe the different kinds of clouds.

4. What is a volcano? What substances are thrown out during an eruption? What probably causes an eruption?

5. Suppose a vessel to sail from North Cape to Cape Horn, through what zones and across what circles would she pass? What ocean currents would she encounter? and state whether they would aid or retard her progress

Civil Government.

Note. — Penmanship, spelling, capitalization and punctuation will be considered in determining the excellence of your paper.

1. How does the form of the government of the town in which you live differ from that of the government of the United States? Is a town government of the same form as that of a city?

2. Name the three kinds of colonial government found in America prior to the Revolution. Show in what respects they differed from each other, and name the colonies that were under each.

3. Who make the laws for the government of the town or city in which you live? What is the official name of the men whose duty it is to see that these laws are executed? By whom and how often are these men chosen? Does the town have a written constitution?

4. Who make the laws for the government of the State in which you live? Where and how often do these law-makers meet? By whom are they chosen? How long do they hold office? What is the official title of the chief executive officer of the State?

5. What is the Congress of the United States? Of how many bodies does it consist, and what is the name of each? How many men has Massachusetts in each of these bodies? How and for how long a time are these men chosen?

6. What is meant by an *executive* officer? What is the official title of the chief executive officer of the United States? Explain carefully how he is elected. For how long a time is he elected?

7. What is the Constitution of the United States? Who framed it? Where and in what year? In what year did it go into effect? Name any of the objects for which the people of the United States ordained and established the Constitution.

8. What is a tax? a poll tax? a property tax? a direct tax? an indirect tax? For what purposes may a town levy a tax upon its citizens? How is the amount of each citizen's tax determined?

9. Why is an education a necessity in a republican government? Why is it right to tax the citizens of a town for the support of public schools? What provision for the support of public schools in the new States of the Northwest did Congress make? Write briefly about the public schools of the town in which you live.

PHYSIOLOGY.

NOTE. — Penmanship, spelling, capitalization and punctuation will be considered in determining the excellence of your paper.

1. Name and locate the cranial bones.

Give a careful description of the skeleton of the trunk.

2. Describe the mechanics of respiration.

How does air once breathed differ from pure air?

3. Give the several functions of the skin.

Tell what you know of the hygiene of the skin.

4. Give the bodily location and the uses of the following organs: the aorta, the optic nerve, the spleen, the larynx and the pharynx.

5. Suppose the hand to touch a hot stove, it is drawn away so quickly as not to be injured; how is this done, and by what means?

ENGLISH GRAMMAR AND COMPOSITION.

NOTE. — Penmanship, spelling, capitalization and punctuation will be considered in determining the excellence of your paper.

1. Name every word in the following sentence; *i.e.*, give its part of speech: —

"The closing years of the nineteenth century will be remembered by Americans as those in which the business prosperity of the country sunk to a remarkably low level."

2. Select from the above (*a*) all words in the *nominative* case; (*b*) all those in the *objective* case. (*c*) Are there any of the *possessive* case in the sentence?

3. Give the principal parts of: recline, fly, beat, fight, fling.

4. Analyze the following: —

"The tramp who came to our door last evening aroused much curiosity; and next morning my father tried to find out the place from which the man had come."

5. Write a sentence upon college education; one upon agriculture.

NOTE. — Each sentence must contain at least twenty words.

6. Define the paragraph. How does it differ from the sentence?

7–9. Write three paragraphs upon one of the following subjects: (*a*) Why I come to college; (*b*) Longfellow's "Evangeline;" (*c*) John G. Whittier; (*d*) General Grant.

10. State clearly and fully the work you have done during the past two years, in school and out, in grammar and rhetoric. Where books can be named, do so.

DEGREES.

Those who complete the four-years course receive the degree of Bachelor of Science, the diploma being signed by the governor of Massachusetts, who is the president of the corporation.

Regular students of the college may also, on application, become members of Boston University, and upon graduation receive its diploma in addition to that of the college, thereby becoming entitled to all the privileges of its alumni.

Those completing the prescribed graduate course receive the degree of Master of Science or Doctor of Philosophy.

EXPENSES.

Tuition in advance: —			
Fall term,	$30 00		
Winter term,	25 00		
Summer term,	25 00		
		$80 00	$80 00
Room rent, in advance, $8 to $16 per term,		24 00	48 00
Board, $2.50 to $5 per week,		95 00	190 00
Fuel, $5 to $15,		5 00	15 00
Washing, 30 to 60 cents per week,		11 40	22 80
Military suit,		15 75	15 75
Expenses per year,		$231 15	$371 55

Board in clubs has been about $2.45 per week; in private families, $4 to $5. The military suit must be obtained immediately upon entrance at college, and used in the drill exercises prescribed. The following fees will be charged for the maintenance of the several laboratories: chemical, $10 per term used; zoölogical, $4 per term used; botanical, $1 per term used by sophomore class, $2 per term used by senior class; entomological, $2 per term used. Some expense will also be incurred for lights and textbooks. Students whose homes are within the State of Massachusetts can in most cases obtain a scholarship by applying to the senator of the district in which they live.

THE LABOR FUND.

The object of this fund is to assist those students who are dependent either wholly or in part on their own exertions, by furnishing them work in the several departments of the college. The greatest opportunity for such work is found in the agricultural and horticultural departments. Application should be made to Profs. William P. Brooks and Samuel T. Maynard, respectively in charge of said departments. Students desiring to avail themselves of its benefits must bring a certificate signed by one of the selectmen of the town in which they are resident, certifying to the fact that they require aid.

ROOMS.

All students, except those living with parents or guardians, will be required to occupy rooms in the college dormitories.

For the information of those desiring to carpet their rooms, the following measurements are given: in the new south dormitory the study rooms are about fifteen by fourteen feet, with a recess seven feet four inches by three feet; and the bedrooms are eleven feet two inches by eight feet five inches. This building is heated by steam. In the north dormitory the corner rooms are fourteen by fifteen feet, and the annexed bedrooms eight by ten feet. The inside rooms are thirteen and one-half by fourteen and one-half feet, and the bedrooms eight by eight feet. A coal stove is furnished with each room. Aside from this, all rooms are unfurnished. Mr. Thomas Canavan has the general superintendence of the dormitories, and all correspondence relative to the engaging of rooms should be with him.

SCHOLARSHIPS.

Established by Private Individuals.

Mary Robinson Fund of one thousand dollars, the bequest of Miss Mary Robinson of Medfield.

Whiting Street Fund of one thousand dollars, the bequest of Whiting Street, Esq., of Northampton.

Henry Gassett Fund of one thousand dollars, the bequest of Henry Gassett, Esq., of North Weymouth.

The income of the above funds is assigned by the faculty to worthy students requiring aid.

Congressional Scholarships.

The trustees voted in January, 1878, to establish one free scholarship for each of the congressional districts of the State. Application for such scholarships should be made to the representative from the district to which the applicant belongs. The selection for these scholarships will be determined as each member of Congress may prefer; but, where several applications are sent in from the same district, a competitive examination would seem to be desirable. Applicants should be good scholars, of vigorous constitution, and should enter college with the intention of remaining through the course.

State Scholarships.

The Legislature of 1883 passed the following resolve in favor of the Massachusetts Agricultural College: —

Resolved, That there shall be paid annually, for the term of four years, from the treasury of the Commonwealth to the treasurer of the Massachusetts Agricultural College, the sum of ten thousand dollars, to enable the trustees of said college to provide for the students of said institution the theoretical and practical education required by its charter and the law of the United States relating thereto.

Resolved, That annually, for the term of four years eighty free scholarships be and hereby are established at the Massachusetts Agricultural College, the same to be given by appointment to persons in this Commonwealth. after a competitive examination, under rules prescribed by the president of the college, at such time and place as the senator then in office from each district shall designate; and the said scholarships shall be assigned equally to each senatorial district. But, if there shall be less than two successful applicants for scholarships from any senatorial district, such scholarships may be distributed by the president of the college equally among the other districts. as nearly as possible; but no applicant shall be entitled to a scholarship unless he shall pass an examination in accordance with the rules to be established as hereinbefore provided.

The Legislature of 1886 passed the following resolve, making perpetual the scholarships established: —

Resolved, That annually the scholarships established by chapter forty-six of the resolves of the year eighteen hundred and eighty-three be given and continued in accordance with the provisions of said chapter.

In accordance with these resolves, any one desiring admission to the college can apply to the senator of his district for a scholarship. Blank forms of application will be furnished by the president.

EQUIPMENT.

Agricultural Department.

The Farm. — Among the various means through which instruction in agriculture is given, none exceeds in importance the farm. The part which is directly under the charge of the professor of agriculture comprises about one hundred and fifty acres of improved land and thirty acres of woodland. Of the improved land, about thirty acres are kept permanently in grass.

The rest of the farm is managed under a system of rotation, all parts being alternately in grass and hoed crops. All the ordinary crops of this section are grown, and many not usually seen upon Massachusetts farms find a place here. Our large stock of milch cows being fed almost entirely in the barn, fodder crops occupy a prominent place. Experiments of various kinds are continually under trial; and every plat is staked, and bears a label stating variety under cultivation, date of planting, and manures and fertilizers used.

Methods of land improvement are constantly illustrated here, tile drainage especially receiving a large share of attention. There are now some nine miles of tile drains in successful and very satisfactory operation upon the farm. Methods of clearing land of stumps are also illustrated, a large amount of such work having been carried on during the last few years.

In all the work of the farm the students are freely employed, and classes are frequently taken into the fields; and to the lessons to be derived from these fields the students are constantly referred.

The Barn and Stock. — Our commodious barns contain a large stock of milch cows, many of which are grades; but the following pure breeds are represented by good animals, viz., Holstein-Friesian, Ayrshire, Jersey, Guernsey, Aberdeen-Angus and Shorthorn. Experiments in feeding for milk and butter are continually in progress. We have a fine flock of Southdown sheep. Swine are represented by the Chester White, Poland China, Cheshire, Berkshire and Tamworth breeds. Besides work horses, we have a number of pure-bred Percherons, used for breeding as well as for work; and a fine pair of French Coach colts.

The barn is a model of convenience and labor-saving arrangements. It illustrates different methods of fastening animals, various styles of mangers, watering devices, etc. Connected with it are commodious storage rooms for vehicles and machines. It contains silos and a granary. A very large share of the work is performed by students, and whenever points require illustration, classes are taken to it for that purpose.

Dairy School. — Connecting with the barn is a wing providing accommodation for practical and educational work in dairying. The wing contains one room for heavy dairy machinery, another for lighter machinery, both large enough to accommodate various styles of all prominent machines; a large ice-house, a cold-storage room and a room for raising cream by gravity methods, a class room and a laboratory. The power used is an electric motor. This department is steam heated and piped for hot and cold water and steam. In this department has been placed a full line of modern dairy machinery, so that we are able to illustrate all the various processes connected with the creaming of milk, its preparation for market and the manufacture of butter. Special instruction in such work is offered in the dairy course.

Equipment of Farm. — Aside from machines and implements generally found upon farms, the more important of those used upon our farm and in our barn which it seems desirable to mention are the following: reversible sulky plough, broadcast fertilizer distributer, manure spreader, grain drill, horse corn planter, potato planter, wheelbarrow grass seeder, hay loader, potato digger and fodder cutter and crusher. It is our aim to try all novelties as they come out, and to illustrate everywhere the latest and best methods of doing farm work.

Lecture Room. — The agricultural lecture room in south college is well adapted to its uses. It is provided with numerous charts and lantern slides, illustrating the subjects taught. Connected with it are two small rooms at present used for the storage of illustrative material, which comprises soils in great variety, all important fertilizers and fertilizer materials, implements used in the agriculture of our own and other countries, and a collection of grasses and forage plants, grains, etc.

A valuable addition to our resources consists of a full series of Landsberg's models of animals. These are accurate models of selected animals of all the leading breeds of cattle, horses, sheep and swine, from one-sixth to full size, according to subject. We are provided with a complete collection of seeds of all our common grasses and the weeds which grow in mowings, and have also a large collection of the concentrated food stuffs. All these are continually used in illustration of subjects studied.

Museum. — A beginning has been made towards accumulating materials for an agricultural museum. This is to contain the rocks from which soils have been derived, soils, fertilizer materials and manufactured fertilizers, seeds, plants and their products, stuffed animals, machines and implements. It is expected to make this collection of historical importance by including in it old types of machines and implements, earlier forms of breeds, etc. For lack of room the material thus far accumulated is stored in a number of scattered localities, and much of it where it cannot be satisfactorily exhibited.

BOTANICAL DEPARTMENT.

Course of Study. — This department is well equipped to give a comprehensive course in most of the subjects of botany. The course aims to treat of all the more important features connected with the study of plants which have a close bearing upon agriculture, without at the same time deviating from a systematic and logical plan. Throughout the entire course the objective methods of teaching are followed, and the student is constantly furnished with an abundance of plant material for practical study, together with an elaborate series of preserved specimens for illustration and comparison. In the freshman year the study of structural and systematic botany is pursued, with some observation on insect fertilization. This is followed in the first term of the sophomore year by the systematic study of grasses, trees and shrubs, and this during the winter term by an investigation into the microscopic structure of the plant. The senior year is given up entirely to cryptogamic and physiological botany. This includes a study of our common plant diseases, and the simple functions of the plant which it is essential for the agriculturist to become familiar with.

The Botanical Museum contains the Knowlton herbarium, of over ten thousand species of phanerogamous and the higher cryptogamous plants; about five thousand species of fungi, and several collections of lichens and mosses, including those of Tuckerman, Frost, Denslow, Cummings, Müller and Schaerer. It also contains a large collection of native woods, cut so as to show their individual structure; numerous models of native fruits; specimens of abnormal and peculiar forms of stems, fruits, vegetables, etc.; many interesting specimens of unnatural growths of trees and plants, natural grafts, etc.; together with models for illustrating the growth and structure of plants, and including a model of the squash which raised by the expansive force of its growing cells the enormous weight of five thousand pounds.

The Botanical Lecture Room, in the same building, is provided with diagrams and charts of over three thousand figures, illustrating structural, systematic and physiological botany.

The Botanical Laboratory has provision for thirty-four students to work at one time. Each student is provided with a locker, wherein he can dispose of his equipment necessary for study. The laboratory is equipped with Leitz', Reichert's, Bausch and Lomb's, Beck's, Queen's and Tolles' compound microscopes, with objectives varying from four inch to one-fifteenth inch focal length. It also contains four induction coils, including a Du Bois-Reymond induction apparatus and rheocord, a Lippmann capillary electrometer, and various other forms of electrical appliances especially devised for studying the influence of electricity upon the growth of plants. There are also Thoma, Minot and Beck microtomes, a self-registering thermometer and hygrometer, a Wortmann improved clinostat and also one of special construction, an Arthur centrifugal apparatus with electric motor, various forms of self-registering appliances for registering the growth of plants, including a Pfeffer-Baranetsky electrical self-registering auxanometer, a Sach's arc-auxanometer, a horizontal reading microscope (Pfeffer model), various kinds of dynamometers of special construction, respiration appliances, mercurial sap and vacuum gauges, manometers, gas and exhaust chambers, besides various other appliances for work and demonstration in plant physiology. The laboratory is also provided with an Eastman landscape camera, a Bausch and Lomb micro-photographic camera, and a dark closet equipped for photographic and other kinds of work.

Horticultural Department.

Greenhouses. — To aid in the instruction in botany, as well as in floriculture and market gardening, the glass structures contain a large collection of plants of a botanic and economic value, as well as those grown for commercial purposes. They consist of two large octagons, forty by forty feet, with sides twelve feet high and a central portion over twenty feet high, for the growth of large specimens, like palms, tree ferns, the bamboo, banana, guava, olive, etc.; a moist stove twenty-five feet square; a dry stove of the same dimensions; a rose room, twenty-five by twenty feet; a room for aquatic plants, twenty by twenty-five feet; a room for ferns, mosses and orchids, eighteen by thirty feet; a large propagating house, fifty by twenty-four feet, fitted up with benches sufficient in number to accommodate fifty students at work at one time; a vegetable house, forty-two by thirty-two feet; a large propagating house, thirty-six by seventy-five feet, for the growing of carnations, violets and bedding plants; a cold grapery, eighteen by twenty-five feet. To these glass structures are attached three work rooms, equipped with all kinds of tools for greenhouse work. In building these houses as many as possible of the principles of construction, heating, ventilation, etc., have been incorporated for the purposes of instruction.

Orchards. — These are extensive, and contain nearly all the valuable leading varieties, both old and new, of the large fruits, growing under various conditions of soil and exposure.

Small Fruits. — The small-fruit plantations contain a large number of varieties of each kind, especially the new and promising ones, which are compared with older sorts, in plots and in field culture. Methods of planting, pruning, training, cultivation, study of varieties, gathering, packing and shipping fruit, etc., are taught by field exercises, the students doing a large part of the work of the department.

Nursery. — This contains more than five thousand trees, shrubs and vines in various stages of growth, where the different methods of propagation by cuttings, layers, budding, grafting, pruning and training are practically taught to the students.

Garden. — All kinds of garden and farm-garden crops are grown in this department, furnishing ample illustration of the treatment of market-garden crops. The income from the sales of trees, plants, flowers, fruit and vegetables aids materially in the support of the department, and furnishes illustrations of the methods of business, with which all students are expected to become familiar.

Forestry. — Many kinds of trees suitable for forest planting are grown in the nursery, and plantations have been made upon the college grounds and upon private estates in the vicinity, affording good examples of this most important subject. A large forest grove is connected with this department, where the methods of pruning trees and the management and preservation of forests can be illustrated. In the museum and lecture room are collections of native woods, showing their natural condition and peculiarities; and there have been lately added the prepared wood sections of R. B. Hough, mounted on cards for class-room illustration.

Ornamental trees, shrubs and flowering plants are grouped about the grounds in such a way as to afford as much instruction as possible in the art of landscape gardening. All these, as well as the varieties of large and small fruits, are marked with conspicuous labels, giving their common and Latin names, for the benefit of the students and the public.

Tool House. — A tool house, thirty by eighty feet, has been constructed, containing a general store-room for keeping small tools; a repair shop with forge, anvil and work-bench; and a carpenter shop equipped with a large Sloyd bench and full set of tools. Under one-half of this building is a cellar for storing fruit and vegetables. In the loft is a chamber, thirty by eighty feet, for keeping hot-bed sashes, shutters, mats, berry crates, baskets and other materials when not in use.

Connected with the stable is a cold-storage room, with an ice-chamber over it, for preserving fruit, while the main cellar underneath the stable is devoted to the keeping of vegetables.

All the low land south of the greenhouses has been thoroughly underdrained and put into condition for the production of any garden or small fruit crop.

DEPARTMENT OF ZOÖLOGY.

The work in this department begins in the winter term of the sophomore year with human anatomy and physiology, the study of which not only serves as an introduction to zoölogy and veterinary science, but also gives the student a knowledge of the structure and uses of the different organs of the human body and the laws of health. In the fall and winter terms the members of the junior class take zoölogy, which is taught by means of lectures and laboratory work. In the laboratory each student is required to dissect and study a series of typical animals, making drawings of the various organs. During the spring term of this year a course of lectures is given on insects in general, their classification and habits and the various methods of destroying those that are injurious, and more or less time in this connection is devoted to laboratory and field work.

There is a most excellent and carefully arranged museum connected with this department, in which are exhibited, as far as possible, all the native animals of this Commonwealth, together with such species from other parts of the world as are necessary to give completeness or for the instruction of the students. This museum furnishes specimens for illustration in the lectures before the classes, and also for general information to visitors as well as members of the college.

During the senior year such members of this class as elect advanced entomology take a course of more technical lectures, in which the following subjects relating to insects are considered quite at length: external and internal anatomy, embryology, transformations, duration of life, luminosity of insects, the color of insects, parasitic insects, diseases of insects, number of insects in existence, geographical and geological distribution of insects, insect architecture, fertilization of plants by insects, economic entomology, bee-keeping and the literature of insects. The laboratory work of this year consists in part of dissections of the caterpillar, pupa and imago stages of insects, and a critical study of the external anatomy of species of each of the orders of insects, followed by the exercise of determining a group of insects in each order; and, finally, each student is required to prepare a thesis on some insect or group of insects pertaining to the business in which he intends to engage. He is asked at the beginning of the year what business he intends to follow after graduation, and is then advised to prepare his thesis on those insects with which he will most have to deal in the business he has selected. In the preparation of this thesis the work is carried on in the most approved methods, so that he may obtain the most scientific and at the same time practical knowledge of the subject; in fact, the is taught such methods of investigation that, if new insec pests appear on his crops, he will know how to properly investigate them and discover the best and cheapest methods for their destruction. If this thesis when completed contains information of public interest, whether of an economic character or otherwise, it is published, with whatever illustrations are necessary.

This course is primarily for the student of agriculture or horticulture, but, when taken in connection with botany and chemistry, is especially adapted to one wishing to fit himself as a teacher of science in our public schools, or to one intending to study medicine, but in this case his laboratory work would be devoted mainly to histology.

This department is now prepared for and is receiving graduates from this and other colleges, who wish to continue the study of entomology beyond what they were able in their undergraduate course. These advanced studies will fit them for positions in the experiment stations or as State entomologists, and also give them most excellent training as teachers in our high schools and colleges.

VETERINARY DEPARTMENT.

This department is well equipped with the apparatus necessary to illustrate the subject in the class room.

It consists of an improved Auzoux model of the horse, imported from Paris, constructed so as to separate and show in detail the shape, size, structure and relations of the different parts of the body; two *papier-maché* models of the hind legs of the horse, showing diseases of the soft tissues, — wind-galls, bog spavins, etc., also the diseases of the bone tissues, — splints, spavins and ringbones; two models of the foot, one according to Bracy Clark's description, the other showing the Charlier method of shoeing and the general anatomy of the foot; a full-sized model of the bones of the hind leg, giving shape, size and position of each individual bone; thirty-one full-sized models of the jaws and teeth of the horse and fourteen of the ox, showing the changes which take place in these organs as the animals advance in age.

There is an articulated skeleton of the famous stallion, Blackhawk, a disarticulated one of a thoroughbred mare, besides one each of the cow, sheep, pig and dog; two prepared dissections of the fore and hind legs of the horse, showing position and relation of the soft tissues to the bones; a *papier-maché* model of the uterus of the mare and of the pig; a gravid uterus of the cow; a wax model of the uterus, placenta and fœtus of the sheep; showing the position of the fœtus and the attachment of the placenta to the walls of the uterus.

In addition to the above there is a growing collection of pathological specimens of both the soft and osseous tissues, and many parasites common to the domestic animals. A collection of charts and diagrams especially prepared for the college is used in connection with lectures upon the subject of anatomy, parturition and conformation of animals.

Through the kindness of Mr. Henry Adams of Amherst the department has received a large sample collection of the various drugs used in the treatment of the diseases of the domestic animals.

For the benefit of the students, sick or diseased animals are frequently shown them, and operations performed in connection with the class-room work. For the use of the instructor of this department a laboratory has been provided in the old chapel building. It has been equipped with the apparatus necessary for the study of histology, pathology and bacteriology, consisting in part of four improved Zeiss microscopes with one-eighteenth and one-twelfth inch oil immersion objectives, together with the lower powers; a Lautenschlager's incubator and hot-air sterilizer; an Arnold's steam sterilizer and a Bausch and Lomb improved laboratory microtome. This apparatus is used for the preparation of material for the class room and for general investigation.

MATHEMATICAL DEPARTMENT.

At first glance it might appear that mathematics would play a very small part in the curriculum of an agricultural college, and, while it is true that its chief object is of a supplementary nature, it is equally true that, entirely aside from its value as a means of mental discipline, mathematics has a well-defined and practical object to accomplish. In this day of scientific experiment, observation and research on the farm, the advantages of a thorough knowledge of the more elementary branches of mathematics, general physics and engineering must be more than ever apparent; and it is to meet the needs of the agricultural college student in these lines that the work in the mathematical department has been planned.

The mathematics of the freshman, sophomore and junior years are required, those of the senior year elective.

A glance at the schedule of studies will show the sequence of subjects: book-keeping, algebra, geometry and mechanical drawing in the freshman year; trigonometry, mechanical drawing and plane surveying — the latter embracing lectures and field work in elementary engineering, the use of instruments, computation of areas, levelling, etc. — in the sophomore year; general physics with work in laboratory — including mechanics, electricity, sound, light and heat — and descriptive geometry or advanced mechanical drawing in the junior year; and, finally, two electives in the senior year, — mathematics and engineering, respectively.*

The mathematical option includes the following subjects: fall term, plane analytic geometry, embracing a study of the equations and properties of the point, line and circle, and of the parabola, ellipse and hyperbola; winter term, differential calculus; and summer term, integral calculus.

The senior engineering option is designed to give to the student the necessary engineering training to enable him to take up and apply, on the lines of landscape engineering and the development of property, his knowledge of landscape gardening, agriculture, forestry, botany and horticulture. It embraces a course of lectures, recitations and field work on the following subjects: topography, railroad curves, earth work, construction and maintenance of roads, water works and sewerage systems, elementary structures, elementary mechanism, etc.

It is believed that the engineering elective will equip the student to enter a comparatively new field, that of landscape engineering, which is coming more and more prominently before the public attention; for, with the increasing consideration which is being paid to the public health and the development and beautifying of our towns and cities, come fresh needs and opportunities.

Chemical Department.

Instruction in general agricultural and analytical chemistry and mineralogy is given in the laboratory building. Thirteen commodious rooms, well lighted, ventilated and properly fitted, are occupied by the chemical department.

The lecture room, on the second floor, has ample seating capacity for seventy students. Immediately adjoining it are four smaller rooms, which serve for storing apparatus and preparing material for the lecture table.

---

* While these two electives are entirely distinct, the student electing engineering is strongly advised to elect mathematics also.

The laboratory for beginners is a capacious room on the first floor. It is furnished with forty working tables. Each table is provided with sets of wet and dry re-agents, a fume chamber, water, gas, drawer and locker, and apparatus sufficient to render the student independent of carelessness or accident on the part of others working near by; thus equipped, each worker has the opportunity, under the direction of an instructor, of repeating the processes which he has previously studied in the lecture room, and of carrying out at will any tests which his own observation may suggest.

A systematic study of the properties of elementary matter is here taken up, then the study of the simpler combinations of the elements and their artificial preparation; then follows qualitative analysis of salts, minerals, soils, fertilizers, animal and vegetable products.

The laboratory for advanced students has tables for thirty workers, with adequate apparatus. This is for instruction in the chemistry of various manufacturing industries, especially those of agricultural interest, as the production of sugar, starch, fibres and dairy products; the preparation of plant and animal foods, their digestion, assimilation and economic use; the official analysis of fertilizers, fodders and foods; the analysis of soils and waters, of milk, urine and other animal and vegetable products.

The balance room has four balances and improved apparatus for determining densities of solids, liquids and gases.

Apparatus and Collections. — Large purchases of apparatus require to be made. Deficiencies caused by the wear and breakage of several years need to be supplied and the original outfit increased. The apparatus includes balances, a microscope, spectroscope, polariscope, photometer, barometer and numerous models and sets of apparatus. The various rooms are furnished with an extensive collection of industrial charts. A valuable and growing collection of specimens and samples, fitted to illustrate different subjects taught, is also provided. This includes rocks, minerals, soils, raw and manufactured fertilizers, foods, including milling products, fibres and other vegetable and animal products and artificial preparations of mineral and organic compounds. Series of preparations are used for illustrating the various stages of different manufactures from raw materials to finished products.

LIBRARY.

This now numbers 18,497 volumes, having been increased during the year, by gift and purchase, 687 volumes. It is placed in the lower hall of the chapel-library building, and is made available to the general student for reference or investigation. It is especially valuable as a library of reference, and no pains will be spared to make it complete in the departments of agriculture, horticulture, botany and the natural sciences. It is open a portion of each day for consultation, and an hour every evening for the drawing of books.

PRIZES.

BURNHAM RHETORICAL PRIZES.

These prizes are awarded for excellence in declamation, and are open to competition, under certain restrictions, to members of the sophomore and freshman classes.

FLINT PRIZES.

Mr. Charles L. Flint of the class of 1881 has established two prizes, one of thirty dollars and another of twenty dollars, to be awarded, at an appointed time during commencement week, to the two members of the junior class who may produce the best orations. Excellence in both composition and delivery is considered in making the award.

GRINNELL AGRICULTURAL PRIZES.

Hon. William Claflin of Boston has given the sum of one thousand dollars for the endowment of a first and second prize, to be called the Grinnell agricultural prizes, in honor of George B. Grinnell, Esq., of New York. These two prizes are to be paid in cash to those two members of the graduating class who may pass the best written and oral examination in theoretical and practical agriculture.

HILLS BOTANICAL PRIZES.

For the best herbarium collected by a member of the class of 1898 fifteen dollars is offered, and for the second best a prize of ten dollars; also a prize of five dollars for the best collection of dried plants from the college farm.

The prizes in 1897 were awarded as follows: —

Burnham Rhetorical Prizes: Edwin M. Wright (1899), first; Warren E. Hinds (1899), second; Allen L. March (1900), first; Francis G. Stanley (1900), second.

Flint Oratorical Prizes: Randall D. Warden (1898), first; John P. Nickerson (1898), second.

Grinnell Agricultural Prizes: Liberty L. Cheney (1897), first; Philip H. Smith, Jr. (1897), second.

Hills Botanical Prizes: John M. Barry (1897), first; Clayton F. Palmer (1897), second.

Prize in Drawing, given by William H. Armstrong, '99; Edwin K. Atkins (1900).

Senior Prizes, given by Charles S. Crocker, '89, and Henry L. Russell, '90; best thesis, James L. Bartlett; best appearance, Charles I. Goessmann.

RELIGIOUS SERVICES.

Students are required to attend prayers every week-day at 8 A.M. and public worship in the chapel every Sunday at 10.30 A.M. Further opportunities for moral and religious culture are afforded by a Bible class taught by one of the professors during the hour preceding the Sunday morning service and by religious meetings held on Sunday afternoon and during the week, under the auspices of the College Young Men's Christian Association.

LOCATION.

Amherst is on the New London Northern Railroad, connecting at Palmer with the Boston & Albany Railroad, and at Miller's Falls with the Fitchburg Railroad. It is also on the Central Massachusetts Railroad, connecting at Northampton with the Connecticut River Railroad and with the New Haven & Northampton Railroad.

The college buildings are on a healthful site, commanding one of the finest views in New England. The large farm of three hundred and eighty-three acres, with its varied surface and native forests, gives the student the freedom and quiet of a country home.

REPORTS.

GIFTS.

From Massachusetts Society for Promoting Agriculture, one hundred dollars to be distributed in prizes in the Dairy School.

J. D. W. French of Boston, seven volumes Hough's "American Woods."

John A. Cutter (M. A. C., '82) of New York, forty-five volumes medical works.

Frederick W. Morris (M. A. C., '72) of New York, forty-four volumes miscellaneous works.

Creamery Package Manufacturing Co., of Chicago, Ill., Disbrow combined churn and butter worker.

F. B. Fargo & Co. of Lake Mills, Wis., Fargo combined churn and butter worker.

I. S. Johnson & Co. of Boston, two large cans Sheridan's condition powders.

L. H. Reed of Grand Rapids, Mich., seed of Panicum crus-galli gigantic.

Rogers & Hubbard Company of Middletown, Conn., one hundred pounds raw knuckle bone flour.

Bradley Fertilizer Company of Boston, two hundred pounds extract fine-ground South Carolina rock, five hundred pounds soft Florida rock, two hundred pounds hard Florida rock, two hundred pounds dissolved bone meal, one hundred pounds steamed bone meal and two hundred pounds acid phosphate.

Barteledes & Co. of Lawrence, Kansas, seed of Idaho field pea, white Kaffir corn, red Kaffir corn, black chaff Kaffir corn or African millet, yellow millo maize, black rice corn, Jerusalem corn, brown Dourha, Brazilian stooling flour corn.

United States Department of Agriculture of Washington, D.C., seed of many varieties of grasses and alfalfa.

Herbert Myrick (M. A. C., '82) of Springfield, "Sugar, a New and Profitable Industry in the United States."

From Samuel B. Green (M. A. C., '79) of St. Anthony Park, Minn., "Vegetable Gardening."

Herbert S. Carruth (M. A. C., '75) of Ashmont, "George Washington;" "True George Washington."

Hon. George F. Hoar of Washington, D.C., fifteen volumes government reports.

J. Willard Brown of Boston, "Signal Corps of the United States in the War of the Rebellion."

John F. Winchester (M. A. C., '75) of Lawrence, "Bovine Diphtheria."

Riehlé Co. of Pennsylvania, "Digest of Physical Tests."

James C. Houghton of Montpelier, Vt., "Cambridge of 1896."

Charles I. Goessmann (M. A. C., '97) of Amherst, "Introduction to General Chemistry;" "True Atomic Weight of the Chemical Elements;" "Literary History of the American Revolution."

Miss Eleanor A. Ormerod of Spring Grove, England, "Twentieth Report of Observations on Injurious Insects."

Joseph E. Pond, Esq., of North Attleborough, four volumes bee journals.

William H. Caldwell (M. A. C., '87) of Peterboro, N.H., "Herd Register American Guernsey Cattle Club."

Charles L. Flint (M. A. C., '81) of Brookline, "Reports Boston Transit Commission."

TREASURER'S REPORT.

Report of GEORGE F. MILLS, *Treasurer of Massachusetts Agricultural College, from Jan. 1, 1897, to Jan. 1, 1898.*

	Received.	Paid.
Cash on hand Jan. 1, 1897,	$4,309 98	–
State treasurer,	15,333 33	–
Term bill,	3,213 48	$757 28
Salary,	250 00	26,987 40
Horticultural department,	4,495 85	6,366 70
Farm,	5,810 00	11,352 98
Expense,	1,410 00	9,163 19
Endowment fund,	11,791 97	–
State scholarship fund,	15,000 00	–
Labor fund,	5,000 00	5,849 65
Botanical laboratory,	65 00	48 46
Chemical laboratory,	585 04	478 17
Entomological laboratory,	30 00	5 76
Zoölogical laboratory,	32 00	45 95
Grinnell prize fund,	40 00	35 00
Gassett scholarship fund,	42 50	80 00
Whiting street fund,	51 05	30 00
Mary Robinson fund,	38 84	55 00
Burnham emergency fund,	129 04	80 00
Hills fund,	356 16	292 36
Library fund,	421 98	221 06
Extra instruction,	–	288 00
Advertising,	–	677 38
Dairy school,	558 78	1,241 58
Electric equipment,	754 92	3,132 33
Insurance,	–	478 57
Investment, N. Y. C. & H. R. R. R.,	4 00	–
Burnham emergency fund,	2,000 00	–
Cash on hand Jan. 1, 1898,	–	4,054 10
	$71,720 92	$71,720 92

This is to certify that I have this day examined the accounts of George F. Mills, treasurer of Massachusetts Agricultural College, from Jan. 1, 1897, to Jan. 1, 1898, and find the same correct, properly kept, and all disbursements vouched for, the balance in the treasury being four thousand and fifty-four dollars and ten cents ($4,054.10), which sum is shown to be in the hands of the treasurer.

CHARLES A. GLEASON, *Auditor.*

AMHERST, Dec. 27, 1897.

Cash Balance, as shown by the Treasurer's Statement, belongs to the Following Accounts:

Hills fund,	$254 14
Burnham emergency fund,	49 04
Grinnell prize fund,	25 00
Gassett scholarship fund,	23 52
Whiting Street fund,	10 46
Mary Robinson fund,	4 76
General fund of the college,	3,687 18
	$4,054 10

Bills receivable Jan. 1, 1898.

Term bill,	$737 14
Horticultural department,	335 34
Farm,	898 22
Expense,	69 02
Labor fund,	7 23
Electric equipment,	145 95
Botanical laboratory,	32 50
Chemical laboratory,	294 00
Entomological laboratory,	6 00
Zoölogical laboratory,	68 00
	$2,593 40

Bills payable Jan. 1, 1898.

Term bill,	$43 23
Horticultural department,	438 44
Farm,	2,405 24
Expense,	567 69
Chemical laboratory,	89 08
Zoölogical laboratory,	27 45
Hills fund,	45 81
Insurance,	18 00
	$3,634 94

Inventory — real estate.

Land (Estimated Value).

College farm,	$37,000 00	
Pelham quarry,	500 00	
Bangs place,	1,750 00	
Clark place,	4,500 00	
		$43,750 00

Buildings (Estimated Value).

Drill hall,	$5,000 00	
Powder house,	75 00	
Gun shed,	1,500 00	
Stone chapel,	30,000 00	
South dormitory,	35,000 00	
		71,575 00
Amount carried forward,		$115,325 00

Amount brought forward,		$115,325 00
North dormitory,	$25,000 00	
Chemical laboratory,	8,000 00	
Entomological laboratory,	3,000 00	
Farm house,	2,000 00	
Horse barn,	5,000 00	
Farm barn and dairy school,	33,000 00	
Graves house and barn,	2,500 00	
Boarding house,	2,000 00	
Botanic museum,	5,500 00	
Botanic barn,	2,500 00	
Tool house,	2,000 00	
Durfee plant house and fixtures,	13,000 00	
Small plant house, with vegetable cellar and cold grapery,	4,700 00	
President's house,	6,500 00	
Dwelling houses, purchased with farm,	5,000 00	
		119,700 00
		$235,025 00

PERSONAL PROPERTY.

Electric equipment,	$6,000 00
Electric supplies,	88 59
N. Y. C. & H. R. R. R. stock,	100 00
Botanical department,	3,610 00
Horticultural department,	8,668 20
Farm,	15,933 20
Chemical laboratory,	1,986 00
Botanical laboratory,	2,056 53
Zoölogical laboratory,	1,894 75
Natural history collection,	5,278 85
Veterinary department,	1,615 66
Physics and mathematics,	4,513 00
Agricultural department,	3,267 58
Library,	18,050 00
Fire apparatus,	665 00
Furniture,	550 00
Books in treasurer's office,	241 16
Tools and lumber,	209 57
	$74,728 09

SUMMARY.

Assets.

Total value of real estate, per inventory,	$235,025 00
Total value of personal property, per inventory,	74,728 09
Bills receivable,	2,593 40
	$312,346 49

Liabilities.

Bills payable,	3,644 94
	$308,711 55

Maintenance Fund.

Technical educational fund, United States grant, ...	$219,000 00
Technical educational fund, State grant, .	141,575 35
	$360,575 35

Two-thirds of the income from these funds is paid to the treasurer of the college and one-third to the Institute of Technology. Amount received by the college treasurer from Jan 1, 1897, to Jan. 1, 1898, ...	$11,791 97
Morrill fund, in accordance with act of Congress, approved Aug. 30, 1890. Amount received in 1897, ...	15,333 33
Hills fund, the gift of Messrs. L. M. and H. F. Hills of Amherst, now amounts to $8,542. By conditions of the gift the income is used for the maintenance of a botanic garden. Income from Jan. 1, 1897, to Jan. 1, 1898, ...	356 16
Annual State appropriation, $10,000. This sum was appropriated for four years by the Legislature of 1889, continued for another four years by the Legislature of 1892, and again by the Legislature of 1896, for the endowment of additional chairs of instruction and for general expense. Five thousand dollars of this sum was set apart as a labor fund, to be used in payment of labor performed by needy and worthy students. Amount received from annual State appropriation for college expense from Jan. 1, 1897, to Jan. 1, 1898, ...	5,000 00
Amount received as labor fund, ...	5,000 00

Scholarship Funds.

State scholarship fund, $10,000. This sum was appropriated by the Legislature of 1896, and is paid to the college treasurer in quarterly payments. Amount received from Jan 1, 1897, to Jan. 1, 1898, ...	10,000 00
Whiting Street fund, $1,000. This fund is a bequest without conditions. To it was added, by vote of the trustees, in January, 1887, interest accrued on the bequest, $260. Amount of the fund Jan. 1, 1897, $1,260. Income from Jan. 1, 1897, to Jan. 1, 1898, ...	51 05
Gassett scholarship fund, $1,000. This sum was given as a scholarship by Hon. Henry Gassett. Income from Jan. 1, 1897, to Jan. 1, 1898, ...	42 50
Mary Robinson fund, $858. This fund was given without conditions. The income from it has been appropriated for scholarships to needy and worthy students. Income from Jan. 1, 1897, to Jan. 1, 1898, ...	35 84
Amount carried forward, ...	$47,610 85

Amount brought forward, ...	$47,610 85

PRIZE FUNDS.

Grinnell prize fund, $1,000. This fund is the gift of Ex-Gov. William Claflin, and is called Grinnell fund in honor of his friend, George B. Grinnell, Esq. The income from it is appropriated for two prizes to be given to the two members of the graduating class who pass the best examination in agriculture. Income from Jan. 1, 1897, to Jan. 1, 1898, ...	40 00

MISCELLANEOUS FUNDS.

Library fund for the benefit of the library. Amount of fund, Jan. 1, 1898, $10,046.12.	
Burnham emergency fund, $5,000. This fund is a bequest of Mr. T. O. H. P. Burnham, late of Boston, and was made without conditions. The trustees have voted that this fund be kept intact, and that the income from it be used by the trustees for such purposes as they believe to be for the best interests of the college. Income from Jan. 1, 1897, to Jan 1, 1898, ...	129 04
Income from Jan. 1, 1897, to Jan 1, 1898, ...	$47,779 89

To this sum should be added amount of tuition and room rent and receipts from sales from farm and from botanic gardens. These amounts can be learned from treasurer's statement, tuition and room rent being included in term bill account.

Report of the President of the Massachusetts Agricultural College to the Secretary of Agriculture and the Secretary of the Interior, as required by Act of Congress of Aug. 30, 1890, in Aid of Colleges of Agriculture and the Mechanic Arts.

I. Condition and Progress of the Institution, Year ended June 30, 1897.

The college has begun to recover from the effects of the hard times experienced during the past two years, and it is evident, from the improved tone and numbers in the entering classes, that the tide has passed its ebb and begun to flow back. In the regular course descriptive geometry has been dropped, and practical work in laboratory physics substituted. In the elective studies, courses in geology and modern history are offered. The dairy and short winter courses were opened for the first time this year, seventeen availing themselves of their advantages. The twenty acres purchased by the State and added to the college domain have been utilized by the horticultural department, and the ground broken up and prepared for orchards and nurseries.

This year closes the thirtieth of the existence of the college. Excluding those at present pursuing their studies, 1,093 have been admitted to its benefits. Of these, 1,001 are living, distributed as follows: 503 in agriculture and the mechanic arts, 498 in business and the various professions in life.

II. Receipts for and during the Year ended June 30, 1897.

1.	Balance on hand July 1, 1896,	$578 96
2.	State aid: (*a*) Income from endowment,	3,820 23
	(*b*) Appropriations for building or other special purposes,	12,000 00
	(*c*) Appropriation for current expenses,	15,000 00
3.	Federal aid: (*a*) Income from land grant, act of July 2, 1862,	7,300 00
	(*b*) For experiment stations, act of March 2, 1887,	15,000 00
	(*c*) Additional endowment, act of Aug. 30, 1890,	14,666 66
4.	Fees and all other sources,	3,000 00
	Total receipts,	$71,365 85

III. Expenditures for and during the Year ended June 30, 1897.

1. *Instruction* in the subjects specified in section 1, act of Aug. 30, 1890,	$23,000 00
2. *Instruction* in all other subjects, if any, not mentioned in Question 1 of this series,	1,000 00
3. Administrative expenses (president's, secretary's, treasurer's, librarian's salary, clerical service, fuel, lights, etc.),	7,500 00
4. Experiment Station,	15,000 00
Total expenditures,	$46,500 00

IV. Property, Year ended June 30, 1897.

Value of buildings,	$189,275 00
Value of other equipment,	$73,872 78
Value of above property not used for instruction in the subjects specified in section 1 of act of Aug. 30, 1890,	$102,275 00
Total number of acres,	404
Acres under cultivation,	260
Acres used for experiment,	60
Value of farm lands,	$45,000 00
Amount of all endowment funds,	$360,575 35
Number of bound volumes in library,	18,080
Number of pamphlets,	–

V. Faculty during the Year ended June 30, 1897.

	Male.	Female.
1. College of Agriculture and Mechanic Arts, collegiate and special classes,	18	–
2. Number of staff of Experiment Station,	21	1
Total, counting none twice,	32	1

VI. Students during the Year ended June 30, 1897.

1. College of Agriculture and Mechanic Arts, collegiate and special classes,	129
2. Graduate courses,	4
Total, counting none twice,	132

FARM REPORT.

The farm operations of the past year have followed the general lines of the past few years. The work has been mainly confined to the cultivation and securing of our usual crops, and the caring for our rapidly increasing herd.

The peculiarities of the past season have rendered the results less satisfactory than usual. The four months, May, June, July and August, brought a total of about thirty-seven inches rainfall, about twenty-two inches coming in the months of June and July and nearly fifteen inches in the single month July.

This excessive rainfall largely increased the cost of caring for our field crops and securing the hay. It greatly decreased the yield of corn, ruined completely fields of carrots and mangels, caused a considerable portion of the potatoes upon about one-half our total area to rot, and decreased materially our crops of millet and soya beans. On the other hand, it gave us a large rowen crop, which serves in part to offset the losses in other directions.

The number of acres in the various crops of the year were as follows: hay, 78; corn for the silo and for fodder, 23½; field corn, 7; potatoes, 12; oats and pease, 1; soya beans, 3; Japanese barn-yard millet, 4½; beets, ½; carrots, 1; celery, 1¼; and turnips as a second crop, 1⅚.

The several fields and products were as follows: —

Hay. — Old fields (between college buildings and the county road, and including building site of old barn and farm-house), 42 acres: hay, 55 tons, 156 pounds; rowen, 36 tons, 1,289 pounds; total, 91 tons, 1,445 pounds, an average per acre of 2 tons, 368 pounds; fields where grass is grown in rotation, 36 acres: hay, 110 tons, 1,687 pounds; rowen, 34 tons, 1,800 pounds; total, 145 tons, 1,487 pounds, average per acre, 4 tons, 98 pounds. The total hay and rowen crops amount to 237 tons, 952 pounds, an average of a little over 3 tons per acre for the entire farm.

Corn for the Silo. — South flat, 15½ acres: 230 tons; north flat, 7 acres: 57 tons.

Field Corn. — South flat, 7 acres: grain, 281 bushels; stover, 9½ tons. Fodder put into the silo: 5 tons.

Potatoes.—Hatch slope, 6 acres: marketable tubers, 903 bushels; south flat, 6 acres: marketable tubers, 463 bushels.

Japanese Barn-Yard Millet. — North flat, 4½ acres: 29.7 tons.

Soya Beans. — North flat, 3 acres: 17⅗ tons.

Oats and Vetch. — North flat, 1 acre: 12½ tons.

Carrots. — One acre: failure on account of weather, and ploughed up.

Mangels. — One-half acre: failure on account of weather, and ploughed up.

Turnips as a Second Crop. — One and five-sixths acres: 405 bushels.

Celery. — North flat, 1¼ acres: crop estimated to be worth $400.

The system of manuring followed with the several crops is shown in the following table: —

Application per Acre.

	Old Mowings.	Field Corn.	Potatoes.	Onion Land, Potatoes.	Oats and Pease.	Japanese Millet.	Beets and Carrots.	Beans.	Celery.
Manure (cords), ...	-	5	-	-	4	1	-	3	16
Nitrate of soda (pounds), ...	150	100	240	120	250	175	200	-	450
Plain superphosphate (pounds), . .	-	200	400	400	400	150	300	250	550
South Carolina rock phosphate (pounds),	-	-	-	-	-	-	200	-	-
Dried blood (pounds), ...	-	-	100	50	-	-	-	-	250
Tankage (pounds), ...	-	-	240	120	-	-	150	-	400
Bone meal (pounds), ...	-	-	-	-	-	-	175	-	-
Muriate of potash (pounds), . . .	-	140	-	-	300	100	250	-	350
High-grade sulphate of potash (pounds),	-	-	250	250	-	-	-	250	350
Armour's fertilizer (pounds), . . .	-	-	-	-	-	-	-	-	2,000

Corn for the Silo. — Our principal field of ensilage corn was planted upon land most of which was tile-drained about six years ago. The soil was heavy, and the care of the crop was rendered very expensive on account of the frequent and heavy rains. The total area of this field is 15½ acres. The total labor cost (crop in the silo) was $342. One-half the manure and three-fourths of the fertilizer used are charged to the crop, at $190. The product, 230 tons, is valued at $805 in the silo, leaving the balance of $273 in favor of the crop. The average yield per acre was 15 tons. A small portion of this field which was not tile-drained furnished a most instructive object lesson. This portion of the field was not originally wetter than other portions. The crop, however, upon this part of the field was at the rate of only 4 tons per acre. The variety of corn cultivated in this field was the Leaming Field.

Field Corn. — The area devoted to this crop comprised 7 acres in the large field known as the south flat. The land had produced corn the previous year. This portion of the field is not tile-drained. It apparently needed this improvement much less than other parts of the field, but the past season has given us so much rain that the crop of corn this year was seriously injured. Upon a portion of the field it was so poor that it was cut and put into the silo, 5 tons of fodder being secured. The balance of the field gave us 281 bushels of grain, an average of about 40 bushels per acre, which is not much more than one-half our usual crop. The crop is to be charged with manure and fertilizer to the amount of $102, and labor $155.13, — a total cost of $257.13. The crop is worth about $200, leaving a balance of about $57 against the crop.

Potatoes. — Of the total area of 12 acres, one-half had a thoroughly drained medium loam and gave a fair crop. This portion of our potato land produced grass and clover in 1896. It is to be charged with fertilizer, $62.46 (three-fourths of the total used); seed, $42; Paris green, $2.56; labor, $201. The crop was dug before the vines were dead, and the work was done by hand. We obtained 903 bushels of marketable potatoes, which sold at 80 cents per bushel, amounting to $722.40, leaving a balance in favor of the crop of $414.38. The other 6 acres of potato land was upon soil which suffered from the excessive rainfall. One-half this land was in onions in 1896 and the balance in root crops. The fertilizer used is charged against the crop at $28.80; seed, $42; Paris green, $2.52; labor, $183.91; total, $257.23. A portion of the crop, as it was found to be rotting, was dug early by hand and disposed of at once; but the greater part of the field was left until the rotting had ceased, when it was dug by machine. That part of the field dug as soon as the rot was noticed gave a larger yield than the portion which was allowed to remain. The total yield of the 6 acres was only 463 bushels of sound, marketable tubers. These were sold for $372.40, leaving a balance in favor of the crop of $113.17.

Soya Beans. — These were grown on the north flat, occupying land that produced potatoes in 1896. The crop suffered seriously from the unfavorable season. The yield was only 17⅗ tons of green fodder, most of which was put into the silo. The crop is charged for manure and fertilizer, $66.35; for labor, $55.95; a total of $122.30, leaving a balance against the crop of $51.90.

Japanese Millet. — Four and one-half acres of the barn-yard variety of Japanese millet were grown upon the north flat. The crop is charged for manure and fertilizer, $24.45; for labor, $51.25; a total of $75.70. The crop was cut green and put into the silo, two parts of this millet to one of soya beans. The yield of millet was 297 tons, estimated to be worth in the silo $89.90, leaving a balance of $13.40 in favor of the crop.

Oats and Pease. — This crop occupied 1 acre on the north flat, and was grown at a cost for manure and fertilizers of $16.30 and labor $14.67; a total of $30.97. The yield was 12½ tons of fodder, which was fed green. This was estimated at $3 per ton, giving a total value of $37.50; leaving a balance of $6.53 in favor of the crop.

Celery. — This crop occupied 1¼ acres upon the north flat. The total cost of producing it and putting into the pit that portion not marketed from the field was $216. The crop is charged with manures and fertilizers, $71.75; labor, $144.25 (the last item including harvesting and preparing for market of the Dwarf Paris Golden variety, which was grown between the rows of the Pascal variety). The Dwarf Paris Golden was of fairly good quality, but sold at a low price, bringing in only $100. The Pascal celery was of remarkably fine quality, and is now about ready for market. It is estimated to be worth about $300, thus making the total probable returns from the field about $400.

Live Stock.

Horses. — Our horses and colts have all gone through the year in perfect health. We now own the following animals: Percherons, 1 stallion, 1 mare and 1 stallion colt; Percherons three-quarters blood, 2 mares; Percheron one-half blood, 1 mare; French Coach, 1 stallion colt, 1 mare colt; ordinary work horses, 1 stallion, 2 geldings, 2 mares; total, 13.

Neat Cattle. — Shorthorn, 1 male and 1 female; Ayrshire, 2 males, 2 females; Holstein-Friesian, 1 male, 2 females; Guernsey, 1 male, 2 females; Aberdeen-Angus, 1 female; grade Hereford, 1 female; Dakota cows and heifers, 39; grades (Jersey, Guernsey, Holstein-Friesian, Ayrshire and Shorthorn), 2-year-old, 7 females; 1-year-old, 18 females; grade (Jersey and Guernsey) cows, 17; grade Hereford, 1 heifer; total 101.

Southdown Sheep. — Thirty-one breeding ewes, 4 ewe lambs, 1 breeding buck, 1 yearling buck, 3 buck lambs; total, 40.

Swine. — Tamworth, 1 boar, 1 sow, 5 pigs; Chester White, 1 boar, 1 sow; Cheshire, 1 boar; Berkshire, 1 boar, 1 sow; Poland-China, 1 sow; Berkshire and Poland-China, cross-bred, 6 pigs, 2 fat hogs; Chester White and Cheshire, cross-bred, 2 fat hogs; common stock, 11 pigs; total, 34.

The general health of the cattle, sheep and swine has been good throughout the year and the breeding increase satisfactory.

Improvements.

The chief improvement of the year has been the moving and fitting up for a quarantine stable of the sheep shed formerly connected with the State Experiment Station barn. This shed is about twenty by forty feet, and has been moved to the foot of the Hatch slope and joined to the quarantine sheds which we already had there. It has been conveniently fitted up to accommodate fifteen cows.

The roads, bridges and drains of the farm have required an unusual amount of attention, on account of the excessively heavy rains. The roads have been badly washed and gullied, bridges have been washed out, streams have made for themselves new courses, and numerous breaks and washouts have occurred in the lines of drains. The repairing of damages of this description has involved much work and considerable expense.

No extensive land improvements have been made during the year.

Cash Receipts of the Year.

The total receipts for the year for products sold and labor performed amounted on December 10 to $5,775.06. The leading items were the following: milk and cream, $2,664.44; potatoes, $865.27; hay, $518.82; beef, $250.10; live stock, $227.75; labor, $191.73; and celery, $149.97. There is now due to the farm for products sold to date this year $902.18, making a total of receipts of $6,677.24.

In conclusion, I desire to testify to the continued faithful services of the farm superintendent, Mr. E. A. Jones. Amid circumstances in many respects difficult and in my absence during the greater part of the year, he has devoted himself, with an eye single to its interests, to the management of the farm. In a season when on every hand farmers abandoned crops, leaving fields to grow to weeds, he has given all fields clean culture, and succeeded in most instances in securing fair crops where others failed.

WM. P. BROOKS,
Professor of Agriculture.

AMHERST, Dec. 24, 1897.

MILITARY DEPARTMENT.

Amherst, Mass., Dec. 20, 1897.

To President H. H. Goodell, *Massachusetts Agricultural College.*

Sir: — In compliance with instructions from your office, I have the honor to submit the annual report of the military department of the college for the year 1897.

The organization of the battalion last year was faulty in that the officers were more numerous than the number of privates warranted, with the result that there was little interest taken in the drill. At the commencement of the fall term the cadets were reorganized, with a cadet major, cadet adjutant, cadet sergeant major, cadet quartermaster sergeant, a drum and trumpet corps and two companies of thirty-five privates and non-commissioned officers each. The effects of this step are seen in the increased interest of the cadet officers and efficiency of the battalion.

Drills commenced on September 13, and have been held on Monday, Tuesday and Thursday of each week.

The seniors have received instruction in signalling with flag and heliograph, and, with one exception, are proficient.

The juniors and sophomores have been instructing the freshmen in squad drill, and the sophomores have received some instruction in target practice at one, two, three and four hundred yards.

Companies have been drilled by their company officers under my supervision, and a good knowledge of company drill has been obtained up to platoon movements. The battalion is well instructed in the new manual of arms, as modified by the War Department, for the Springfield rifle, and is also very efficient in the bayonet exercise.

The attendance at drill has been very good. The average of daily absentees for this fall term is 3.7, against 5 for the same time last year.

The drum corps is efficient and interested in its work, but the trumpet corps is not up to a proper standard, owing to lack of proper instruction. I recommend that a good drum and trumpet instructor be engaged to give instruction in the field music once a week during the winter term.

The dormitories are in better condition than last year. North college has been provided with a bath-room and lavatories, which makes the building much more comfortable and convenient. I recommend that the painting of the bath-rooms and lavatories in south college be completed. This work was commenced about a year ago, and has never been finished. The place needs painting very much, and should not be left half done.

It would be economy to give the drill hall a thorough painting on the outside, and I renew my recommendations of last year relative to making the present armory a locker room where the students can keep their athletic clothes and equipments. The gun shed would be suitable for an armory and gun shed combined.

The college fire department has been reorganized and partially re-equipped, and is in efficient condition. The new water system of the college gives excellent fire protection.

The new target pit and butt is entirely satisfactory, and affords ample protection to the cadets working there.

The following three members of the class of '97 were reported to the Adjutant-General of the Army and the Adjutant-General of the State of Massachusetts as having shown the greatest proficiency in the art and science of war: —

Cadet First Lieutenant and Adjutant, . .	G. D. LEAVENS.
Cadet First Lieutenant and Fire Marshal, .	H. J. ARMSTRONG
Cadet Second Lieutenant, ...	H. F. ALLEN.

The following is a list of the United States property now on hand: —

Ordnance.

2 3.2-inch B. L. field guns.
2 8-inch mortars, with implements.
2 gun carriages
2 gun caissons with spare wheels.
2 mortar beds
147 Springfield cadet rifles.
147 sets in infantry accoutrements.
51 headless shell extractors.
4,250 metallic ball cartridges.
2 mortar platforms.
2,000 pasters.
75 paper targets.
30,000 cartridge primers.
20,000 round balls.
1 set reloading tools.
75 pounds small arms powder
2 sets implements and equipments for 3.2-inch B. L. field guns.

Signal.

2 heliographs, complete.
6 2-foot white flags.
6 2-foot red flags.
6 canvas cases and straps.
12 joints of staff.

The following are the officers of the battalion: —

Commandant.

First Lieut. W. M. Wright,	Second U. S. Infantry.

Field and Staff.

Cadet Major,	R. D. Warden.
Cadet Adjutant,	W. S. Fisher.

Company A.

Cadet Captain,	A. Montgomery, Jr.
Cadet First Lieutenant,	J. P. Nickerson.
Cadet Second Lieutenant,	C. G. Clark.

Company B.

Cadet Captain,	G. H. Wright.
Cadet First Lieutenant,	C. N. Baxter.
Cadet Second Lieutenant,	J. S. Eaton.

Respectfully submitted,

WM. MASON WRIGHT,
First Lieutenant Second U. S. Infantry.

THE PTEROPHORIDÆ OF NORTH AMERICA.

C. H. FERNALD, A.M., PH.D.

Massachusetts Agricultural College.

January, 1898.

THE PTEROPHORIDÆ OF NORTH AMERICA.

The species of moths taken up in this work are known by the common names of plume-moths and feather-wings. They have been studied but very little, and our knowledge of the early stages and habits of a large proportion of our native American species is very imperfect, but it is hoped that our entomologists will give more attention to them hereafter.

GEOGRAPHICAL DISTRIBUTION.

The Pterophoridæ are distributed very widely over the globe, but appear to be most numerous in the temperate regions, particularly in Europe, North America and Australia; yet, when other parts of the globe have been as carefully explored, it is probable that many additional species will be discovered, and that they may be more evenly distributed than at present appears to be the case.

GEOLOGICAL DISTRIBUTION.

I am indebted to Mr. S. H. Scudder, our highest authority on fossil insects, for the information that no Pterophoridæ have yet been recognized among the fossils, not even in amber.

ECONOMIC IMPORTANCE.

A few species of the Pterophoridæ are injurious to plants of economic importance, and the larvæ of several others feed on plants raised for ornamental purposes or for flowers.

NATURAL ENEMIES.

While it is probable that the species of this family are preyed upon not only by insect enemies but also by birds, yet I have been able to find but few recorded observations with regard to them. Ashmead has described *Pimpla pterophori* and *Limneria pterophoræ* from Pterophorids in California, and the latter species has also been taken in Texas. Prof. Kellicott bred *Ichneumon humilis* Prov. from *Platyptilia carduidactyla*.

HISTORY.

Linnæus, in the tenth edition of his "Systema Naturæ," Vol. 1, page 542, published in 1758, established the genus *Alucita* for the plume-moths with the following six species under it in order: *monodactyla*, *didactyla*, *tridactyla*, *tetradactyla*, *pentadactyla* and *hexadactyla*, — all placed under the heading ALUCITÆ. Some of these insects had been figured and described more or less fully by authors previous to the time of Linnæus, as Aldrovandus, 1602; Madam Merian, 1679; Petiver, 1702; Ray, 1710; Frisch, 1721; Reaumur, 1736; and Rosel, 1746; but, as Linnæus in the above work first consistently used the binomial nomenclature, it has been decided almost universally by zoölogists to adopt this edition of the "Systema Naturæ" as the starting-point in zoölogical nomenclature.

In 1761, Poda published his "Insecta Musei Graecencis," in which, on page 94, he adopted the generic name *Alucita* with *pentadactyla* L. the only species under it, and this species is therefore regarded as the type of the genus *Alucita* by Lord Walsingham and other eminent authorities. Geoffroy, in 1762, published the first edition of his "Histoire abrégée des Insectes," in two volumes. In the second volume this author, rejecting the genus *Alucita* of Linnæus, established the genus *Pterophorus*, a name which he stated was given to these insects by some naturalist in former times, and placed under it *pentadactyla* L. *didactyla* L. and *hexadactyla* L. From his description of *didactyla*, there can be no doubt that, instead of this species, he had *monodactyla* L. before him, and therefore we must consider *didactyla* Geoff. the same as *monodactyla* L. As Poda had already used *pentadactyla* as the type of *Alucita*, only the species *monodactyla* L. and *hexadactyla* L. could be considered as belonging under *Pterophorus*.

Scopoli, in his "Entomologia Carniolica," published in 1762, gives five species of plume-moths under Phalæna, which he appears to have used in a generic sense. In 1775, Fabricius, in his "Systema Entomologiæ," page 667, very improperly made use of the genus *Alucita* for *xylostella* L. and nineteen other Tineids, and followed Geoffroy in using *Pterophorus* for the plume-moths. This use of these generic names he continued through all his writings. The authors of the "Systematische Verzeichniss der Schmetterlinge der Wienergegend," 1776, page 144, adopted the genus *Alucita* in the strict Linnæan sense.

Latreille, in his "Precis des Caracteres generique des Insectes," published in 1796, page 148, separated *hexadactyla* from the group and established for it the genus *Orneodes*, but retained the rest of the plume-moths under Pterophorus. Latreille repeated this use of these generic names in his "Histoire naturelle des Crustaces et Insectes," Vol. XIV., page 255 (1805), and used the generic name *Alucita* in the Fabrician sense. This action of Latreille in removing *hexadactylus* from *Pterophorus* left only the species *monodactylus* L. under it which must now be regarded as the type, while *Orneodes* must be recognized with *hexadactyla* L. as the type.

In 1806 Hübner published his "Tentamen," in which these insects are placed in Phalanx 9; Alucitæ, in Tribus 1: *indubitate.* There are two divisions under this, the first of which is Pterophoræ with *Pterophora pentadactyla*, and the second is Ripidophoræ with *Ripidophora hexadactyla.* The "Tentamen" has caused a great deal of controversy as to whether it was a true publication, and whether its generic names should be recognized. No question can arise in case of the plume-moths, as Poda had long before adopted *pentadactyla* as the type of *Alucita*, and Latreille had very properly separated *hexadactyla* from the group and established for it the genus *Orneodes.* Schrank, in the second part of Vol. II. of his "Fauna Boica" (1802), page 139, adopted the Linnæan genus *Alucita* for these insects.

In 1811 Haworth published the third part of his "Lepidoptera Britannica," in which he adopted the genus *Alucita* in the Linnæan sense for the plume-moths. In 1815, Leach published his article "Entomology" in the "Edinburgh Encyclopædia," in which, under Tribe VII, Alucitides, the genus *Pterophorus* Geoff. is adopted with *pentadactylus* and *didactylus* under it, and the genus *Alucita* with *hexadactyla* under it. In 1819 Samoulle published his "Entomologist's Useful Compendium," in which he adopted the classification of Leach.

Hübner, in his "Verzeichniss bekannter Schmetterlinge," adopted the term Alucitæ for his ninth phalanx, the plume-moths. This part of the "Verzeichniss" was published between Aug. 27, 1825, and the time of Hübner's death, which occurred Sept. 13, 1826. This author divided these insects into three tribes: the first including those with unfissured wings, for which he established the genus *Agdistis;* the second with those having one fissure in the fore wings and two in the hind wings. This tribe was further divided into two families, each containing two genera. The first family, Obtusæ, contained the genera *Platyptilia* and *Amblyptilia*, and the second family, Cuspides, contained the genera *Stenoptilia* and *Aciptilia.* The third tribe included those species in which each wing is divided into six parts, and these were all placed under the genus *Euchiradia*, which is of course synonymous with *Orneodes*.

In 1827 Curtis published Vol. IV. of his "British Entomology," in which he adopted the genus *Pterophorus* and names *pentadactyla* L. as the type. In Vol. X. of the same work (1833), he established the genus *Adactylus* with *adáctyla* Hüb. for the type. In Vol. XV., published in 1838, he adopted the genus *Alucita* and named *hexadactyla* as the type. Curtis, in 1829, in his "Guide to an arrangement of the British insects," had taken the genus *Adactylus* for the species with undivided wings, *Alucita* for "*hexadactyla* and its allies" and *Pterophorus* for the remainder. In the same year Stephens published his "Catalogue of British insects," in which he adopted the genus *Agdistis* Hüb. for the species with undivided wings, and *Pterophorus* and *Alucita* in the same sense as Curtis had used them. This same classification was used by Stephens in 1834, in his "Illustrations of British Entomology."

Treitschke, in Vol. IX., Part 2, of his "Schmetterlinge von Europa," published in 1833, adopted the generic name *Alucita* for the species placed by Stephens under *Agdistis* and *Pterophorus*, while he used *Orneodes* for *hexadactylus* and its allies. In 1836, Duponchel, in his "Histoire naturelle des Lepidopteres," Vol. IX., adopted the classification of Latreille, but in his "Catalogue Methodique," published in 1844, he used the genus *Adactyla* Zell. for *hübneri* Curt., *Orneodes*, for *hexadactyla* and its allies, and *Pterophorus* for the remaining species. Westwood, in Vol. I. of his "Classification of insects," page 115, published in 1839, adopted the classification of Stephens.

Zeller, in 1841, published his monograph of the plume-moths in "Isis," Vol. X. This author adopted the name *Pterophoridæ* for the group, and divided them into the *Pterophoridæ proprii*, and *Alucitina*. Under the first division he established the genus *Adactyla*, apparently unconscious of the fact that Curtis had already used the same name. Under this same division Zeller adopted the genus *Pterophorus* Geoff., which he divided into groups or subgenera as follows: *Platyptilus* (*Platyptilia* Hüb.), *Oxyptilus* (*Amblyptilia* Hüb.), *Pterophorus* (*Stenoptilia* Hüb.), *Aciptilus* (*Aciptilia* Hüb.). The division *Alucitina* contained the genus *Alucita* with *hexadactyla* and allies under it. In 1852, Zeller published his "Revision of the Pterophoridæ" in "Linnæa Entomologia," Vol. VI., page 319, in which he sinks his genus *Adactyla* and adopts Hübner's *Agdistis*, and established the genus *Deuterocopus* for the species *tengstrœmi* of Java.

In 1840, Zetterstedt, in his "Insecta Laponica," placed all his plume-moths under the genus *Alucita*, but in a note refers to *Orneodes hexadactyla* indicating his adoption of this generic name. Herrich-Schæffer, in his "Schmetterlinge von Europa," Vol. V., published in 1853–55, follows the classification of Zeller. Stainton, in his "Manual of British Butterflies and Moths" (1859), adopted the generic name *Adactyla* for *bennetii*, *Pterophorus* for *rhododactylus* and its allies and *Alucita* for *polydactyla*.

In 1859, Wallengren published his work on the Scandinavian plume-moths, which, like Zeller's works, marked an era in the classification of these insects. Wallengren followed Zeller in dividing them into the *Pterophoridæ* and *Alucitina*, under the first of which he established four new genera, and used, in addition to these, five genera established by earlier authors. Under *Alucitina* he adopted the genus *Alucita* for *hexadactyla*.

In 1864, Walker published Part 30 of his "List of the Lepidopterous Insects in the British Museum," in which he refers to all the described species of the plume-moths, and added thirty-five new species and two new genera founded on new species from Ega, South America. In this work Walker followed the classification of Zeller.

In 1869, Dr. Jordan, in the "Entomologist's Monthly Magazine," Vol. VI., pages 119 and 149, gave a review of Wallengren's work, referred to above, which contains valuable information. Mr. South has given a most interesting and valuable series of illustrated papers on the early stages, habits and food plants of the British plume-moths in the "Entomologist," Vol. XIV. and following volumes. Tutt's "Monograph of the Pterophorina of Britain" is also a valuable paper on the British plume-moths. In 1877, Dr. Wocke, in "Die Schmetterlinge Deutschlands und der Schweiz," Vol. II., Part 2, followed very closely the classification of Wallengren. In 1886, Leech, in his "British Pyralides," including the Pterophoridæ published in 1886, uses the super family Pterophori with the families *Pterophoridæ* and *Alucitidæ* under it.

Meyrick, in his paper "On the Classification of the Pyralidina of the European Fauna," published in 1890, in the "Transactions of the Entomological Society of London," placed these insects as families under the super family Pyralidina. Mr. Meyrick had already made critical studies on these insects in his researches on the Lepidoptera of Australia and New Zealand and in the paper above referred to he gave most excellent characters to the families and genera. He adopted the family names *Pterophoridæ* and *Orneodidæ* with the genus *Orneodes* under the last for *hexadactyla* and its allies. In his "Handbook of British Lepidoptera" (1895), Meyrick retains substantially the same classification. The latest and one of the most valuable works that I have seen is "Die deutschen Pterophoriden" by Dr. O. Hofmann (1895). In this work we are given for the first time a very good account of the genitalia, and all stages are described in full so far as known.

The first writer on the North American plume-moths, so far as I am able to learn, was Fitch, in his first "Report on the Insects of New York," page 145 (1856), where he published eight species, placing them under the genus *Pterophorus*. In 1864, Walker published two species from this country under the same genus, in the "Catalogue of the Lepidoptera Heterocera," Part 30, page 940. In 1869, Riley, in his first "Report on the Insects of Missouri," published one new species and gave a more complete description of one of the species of Fitch. In 1873, Packard described three species from California under the genus *Pterophorus*, in the "Annals of the Lyceum of Natural History," Vol. X., page 265. In the same year Zeller, in his "Beitrage," described six new species of the North American plume-moths, and in the same paper established a new genus (*Scoptonoma*) with two new species from Texas. This genus, however, proved to be the same as *Lineodes* of Guenee, a Pyralid genus. The next year Zeller described his *Leioptilus Mathewianus* in his "Lepidoptera der Westkuste Amerika's," page 23. Chambers published *Pterophorus lacteodactylus* in the "Canadian Entomologist," Vol. V., page 265 (1873).

The most important contribution to our knowledge of the North American species of these insects was given by Lord Walsingham in his "Pterophoridæ of California and Oregon," published in 1880. This work contains full descriptions of forty-one species, many of them here published for the first time, and all of the species are illustrated in colors. Lord Walsingham was so generous as to give me co-types of nearly all of his species. In this same year Miss Murtfeldt described two new species with their early stages in the "American Entomologist," Vol. III., page 235. In 1881, Mr. Charles Fish described ten species of these moths in the "Canadian Entomologist," Vol. XIII., pages 70 and 140. This gentleman made extensive studies of the Pterophoridæ, and secured the types of Fitch's species and all of his notes on them; but, having abandoned the work because of other engagements, I obtained his entire collection of these insects, including all of his own types as well as those of Fitch. Valuable notes by other writers have also been made, which will be referred to under the various species on following pages.

Structure.

The Pterophoridæ are small, slim insects, with long, slender legs and long, narrow fore wings, cut by a fissure extending in from the middle of the outer margin between veins 4 and 7, from a fourth to one-half of the length of the wing (plates II. and III.). The parts on each side of the fissure are called lobes, the anterior one being called the first lobe and the other the second lobe. In some of the genera these lobes are narrow and pointed, while in others they are well developed and present two well-marked angles on each, which are called the apex and anal angle (Plate II., fig. 1). The normal number of veins in the fore wings is twelve, but this number is reduced in many of the species. Vein 1 is feebly forked at the base, at least in some of the species, and the cross vein and veins 5 and 6 are very weak, often entirely invisible; 5 and 6 at equal distances from each other and from 4 and 7, extending to the fissure which ends between them. Veins 8 and 9 are stalked and 10 sometimes arises from the same stalk, but is occasionally wanting.

The hind wings have two fissures, the first extending in from the outer margin between veins 4 and 7 to about the middle of the wing; the second, between the inner margin veins and vein 2, extends to about the basal fourth. These divisions are called feathers, the anterior one being called the first feather, the middle one the second feather and the posterior one the third feather (Plate II., fig. 2).

The first feather in some species is somewhat spoon-shaped, rounded at the outer end, widest near the middle and narrower near the base. The costal vein bends down near the middle of its course, approaching very near to the subcostal. The costal vein ends in the costa when this feather tapers gradually to a point and vein 7 ends in the point. When this feather is broad at the outer end and has two angles corresponding to the apex and anal angle, the costal vein usually ends in the apex and vein 7 in the anal angle. The frenulum is single in the male and divided in the female.

The second feather in some species is widest towards the outer end, which is very oblique, but in others it is of the same form as the third feather. The median vein runs into this feather, giving off vein 2 which ends in the hind margin, vein 3 which ends in the anal angle of this feather and vein 4 which ends in the apex. In the narrow, tapering forms vein 4 is wanting and 3 runs to the end of the feather. The cross vein and also veins 5 and 6 are exceedingly fine and scarcely visible under the most favorable circumstances.

The third feather tapers gradually to the more or less blunt outer end, but in some species it has a very obtuse and rounded angle on its hind margin, which represents the anal angle of the wing (Plate II., fig. 2). This feather has a strong vein running through the middle to the end, which is undoubtedly vein 1b. In some species a weak vein may be seen above lying very near the edge of the feather, and in others a shorter vein below running to the hind margin of the feather a little beyond the anal angle. This, without doubt, is vein 1a, and therefore the three internal veins are represented in the Pterophoridæ, but all three do not occur in any one species.

The fringes are long and arranged along both sides of the feathers, giving them a strong resemblance to the feathers of a bird, thus making more complete organs of flight. In some species there are clusters of dark spatulate scales in the hind fringe of the third feather, and similar scales occur along the median vein on the under side of the wing. The basal part of the median vein on the upper side of the hind wings is not provided with a row of fine hairs, as in some families of moths.

The head is of medium size, with the front smooth and vertical in some species but more or less conical in others. The labial palpi are either porrect or curved upward and closely scaled, or more or less bushy. The maxillary palpi are entirely wanting. The proboscis is about as long as the head and thorax, and not clothed with scales at the base. The eyes are nearly hemispherical, naked and without lashes or cilia. The ocelli are absent. The scales of the head lie smooth over the surface, giving it an even appearance; but in some species they form a more or less cone-shaped tuft, extending forward from the front. The antennæ are fine filiform, and about two-thirds as long as the costa of the fore wings. The basal segment is much larger than those beyond, and covered with scales which sometimes form a pointed tuft at the end. The remaining segments are finely ciliated, those in the males being stronger than in the females.

The thorax is of medium size, and its covering of scales smooth without any indication of tufts or other characters. The tegulæ are of medium length, without long scales, hairs or other unusual characters. The abdomen is long and slim, of nearly uniform size throughout in the male, but somewhat fusiform in the female.

The genitalia of the male consist of a pair of long, comparatively thin and broad exserted claspers and a prominent uncus.

The legs are long and slim with cylindrical segments, except the femora, which are somewhat compressed. The coxæ are about as long as the thorax and stouter than the remaining segments of the legs. The fore tibiæ have a tibial epiphysis on the inside near the end, the middle tibiæ have a pair of unequal spurs at the end, while the hind tibiæ have a pair of unequal spurs at the end and a similar pair at the outer third. The tarsi consist of five segments with a pair of claws at the end. There are no spines on any of the segments of the legs, but they are covered by scales that lie smooth and close to the surface. In some species, however, the scales are raised, forming an enlarged ring around the middle and hind legs at the base of the spurs, and a similar ring occurs around the end of the fore tibiæ. In one species (*monodactylus*) there is a small tuft of scales on the hind tibiæ, opposite and within the middle spurs (Plate I., figs. 11, 12). This character is very useful in determining this exceedingly variable and common species.

The ground color of the Pterophoridæ is generally white, yellowish white or some shade of brown, occasionally without darker markings, though the fore wings most frequently have a dark triangular spot resting on the costa and extending down to a point just within the end of the fissure. One or two light lines cross the lobes obliquely, and there is a dark spot on the cell a little before the middle of the wing and another on the fold still nearer the base of the wing. The hind wings are of one uniform color, and seldom have spots or lines of other colors.

Habits.

The usual time of flight is on warm, calm evenings, when they are occasionally attracted to light and rarely to sugar. They may, however, be easily "flushed" in the day time from the shrubbery, when they fly a short distance and alight. When at rest they hold their wings nearly horizontal and at right angles with the body, but the feathers of the hind wings are folded over each other and drawn under the fore wings.

Early Stages.

I am not aware that anything is known of the egg-stage of any of our North American plume-moths, and if any thing has been published on this stage, I have overlooked it. In the European species, so far as I have seen any descriptions, they are more or less oval in outline, smooth and of a pale-green color.

The larvæ are short and stout, pale green, with longitudinal stripes of other colors in some species, and one or more coarse or fine hairs arise from tubercles on the segments. The pupæ are formed above ground, and attached by the anal extremity. Some species are hairy, while others are naked; and they sometimes have a pair of prominent tubercles arising from the back.

It is not known positively whether any of our North American species have more than one generation in a season; but so little is known about them that we cannot speak with any certainty on this point. *Acanthodactyla* and *monodactyla* are said to have two generations in a year in Europe, and very likely this is true here, at least in some parts of the country.

Systematic Position.

Linnæus placed these insects at the end of the Lepidoptera, after the Tineina, and he was followed by later writers till a little more than twenty-five years ago, when it began to dawn upon those who were working upon these insects that they were out of place. At first the matter was talked over, but it was some time before any one seemed to be willing to express such an apparent heterodox opinion in print. Dr. Jordan, however, in 1869 (Ent. Mon. Mag., Vol. VI., p. 152), expressed the opinion that these insects form "an aberrant group of the Pyralidæ." A few years ago, entomologists, both in this country and England, in making critical studies on the early stages as well as on the imago of the Lepidoptera, quite revolutionized the order, not only with regard to the position of the families, but also with regard to the names. I am heartily in sympathy with this movement, and, if I do not always adopt the changes at once, it is because I have not had time to study them carefully and convince myself that they are right.

The genus *Chrysocorys* has been placed among the Pterophoridæ by several of the English entomologists, and Zeller established the genus *Scoptonoma* for two Texan species, placing it in this family; but this genus is identical with *Lineodes* Guen., which both he and Lederer very properly placed among the Pyralids. If these two genera be removed, we have rather a compact group, which may be placed in the vicinity of the Pyralids, in my opinion.

Characters of the Pterophoridæ.

Long, slim insects, with long legs. Fore wings usually with one fissure and hind wings with two. The North American species, so far as known, have fissured wings. Proboscis and labial palpi well developed. Maxillary palpi and ocelli absent.

Fore wings with vein 1 b either simple or with a short fork at the base; 1 c present, 4 and 5 remote at the base, 8 and 9 stalked or fused. Hind wings above without a row of hairs along the basal part of the median vein; 1 a usually absent, 4 and 5 remote at the base, 6 and 7 remote, 7 and 8 approach very near each other near the middle of the wing.

SYNOPSIS OF THE GENERA.

1.	Hind wings with a cluster of black scales in the fringe of the third feather,	2.
	Hind wings without a cluster of black scales in the fringe of the third feather,	4.
2.	Anal angle present in second lobe of fore wings,	3.
	Anal angle absent in second lobe of fore wings,	*Trichoptilus.*
3.	Anal angle absent in first lobe of fore wings,	*Oxyptilus.*
	Anal angle present in first lobe of fore wings,	*Platyptilia.*
4.	Feathers of hind wings similar and tapering uniformly,	*Alucita.*
	Feathers of hind wings unlike in form,	5.
5.	Anal angle present on first lobe of fore wings,	*Stenoptilia.*
	Anal angle absent on first lobe of fore wings,	*Pterophorus.*

GENUS TRICHOPTILUS Wlsm., Pter. Cal. and Ore. (1880).

Front neither extended nor tufted, vertex smooth. Antennæ pubescent; palpi slightly ascending; second and third segments nearly equal in length, the former a little thickened with scales, especially towards the outer end, the latter filiform. Tibiæ thickened with scales at the origin of the spurs. Fissure of the fore wings extending in a little more than half their length, the lobes being very slender, diverging, and without the anal angle on either. Hind wings with the fissure between the first and second feathers reaching within one-fourth of their base, while the second fissure reaches nearly to the base of the wing. All the feathers are very slender, almost filiform, and there is a cluster of black scales in the fringe near the middle of the hind margin of the third feather.

This genus was established by Lord Walsingham on a single species, *pygmæus*, of which his lordship took three specimens near Milville, in Shasta County, California, on the 11th of July, 1871, one of which with his characteristic generosity he gave me. As this single co-type is all I have, I do not feel like injuring it to study the venation or genitalia. Mr. Meyrick, in his "Handbook of British Lepidoptera," has given the venation of the fore wings probably of *T. paludum* Z. as follows: 2 out of 4 or absent, 3 absent, 7 and 9 absent, 10 from near 8 or absent, 11 from near 8.

Hofmann gives a description of the male genitalia and a figure of a paramere of *T. paludum.* He states that the genitalia of the male are distinguished by the remarkable form of the claspers, which are long and narrow, hollow within, and with a broad, bell-shaped, bristly appendage. The tenth dorsal plate is obtusely triangular, arched and bent down at the end. The ninth dorsal and ventral plates offer nothing especially worthy of remark.

SYNOPSIS OF THE SPECIES.

Expanse of wings, 10 mm. or less, . . .	*pygmæus.*
Expanse of wings, 17 mm., ...	*ochrodactylus.*
Expanse of wings, 20 mm., ...	*lobidactylus.*

TRICHOPTILUS PYGMÆUS.

Trichoptilus pygmæus Wlsm., Pter. Cal. and Ore., p. 64, Plate 3, fig. 15 (1880).

Expanse of wings, 10 mm. Head and thorax pale fawn color; antennæ slightly pubescent, marked above with fawn brown and white alternately; palpi whitish touched with fawn color. Abdomen whitish, with a tinge of fawn color on the sides and above posteriorly. Legs white, dotted and barred above with fawn brown; spurs white, and at their origin the legs are thickened with fawn brown scales, among which project some which are white and almost erect. Fore wings very pale fawn color, dusted with fuscous brown scales along the costa, especially above the base of the fissure and near the base of the hind margin. Two indistinct white stripes cross the lobes of the fore wings, one beyond and the other before the middle, cutting the fawn-colored fringes on each side. Hind wings pale grayish brown, with cinereous fringes interrupted with white behind and at the apex. The third feather has long cinereous fringes interrupted with white at the apex, and there is a cluster of dark scales slightly beyond the middle in the fringe of the hind margin.

Habitat. — Shasta County, California. Early stages and food plant unknown.

TRICHOPTILUS OCHRODACTYLUS.

Trichoptilus ochrodactylus Fish, Can. Ent., Vol. XIII., p. 142 (1881).

Expanse of wings, 17 mm. Head and anterior part of the thorax pale ochreous. Antennæ with a longitudinal brown line above, bordered by a fine white line on each side, pale ochreous beneath. Posterior part of thorax and abdomen light cream color, the latter nearly pure white beneath. Legs white, striped longitudinally with pale brownish ochreous; posterior tibiæ with a band of raised ochreous scales before each pair of spurs. Fore wings pale ochreous, approaching to cream color, with a very light brownish tinge on the first lobe. A minute brown spot at the base of the first lobe reaches from the end of the fissure half way to the costa. Costal fringe of the first lobe brownish ochreous, with a longitudinal white spot at the basal third, another at the outer third and a smaller one just before the apex. Fringe of the fissure ochreous and tinged with brown just beyond the middle, and there are some white hairs near the apices. Fringe of hind margin pale ochreous, with a white patch near the middle of the second lobe, beyond which the fringe is rather dark brownish, with a streaklet of white near the apex. Hind wings pale brown, with the fringes slightly paler. The third feather has a cluster of dark-brown scales in the hind fringe, just beyond the middle, and a row of club-shaped white scales extends from this to the base of the wing.

Habitat. — Texas. Early stages and food plant unknown.

TRICHOPTILUS LOBIDACTYLUS.

Pterophorus lobidactylus Fitch, N. Y. Rep., Vol. I., p. 848 (1854).
Aciptilus californicus Wlsm., Pter. Cal. and Ore., p. 60, Pl. II., fig. 9 (1880).

Expanse of wings, 17-20 mm. Head grayish brown, with a while line over each eye; palpi whitish, touched with brown on the outside of the second segment, with a long, slim tuft at the outer end beneath, of nearly the same size and length as the slim outer segment, which is dark brown, as is also the tuft at the end of the second segment. Antennæ grayish beneath, blackish above and dotted with white. Thorax brown, much lighter posteriorly. Abdomen dark brown, with diverging white lines on some of the segments. Legs striped with dark brown and white, with a tuft of dark scales at each pair of spurs; tarsal segments white at the base and brown at the outer end.

Fore wings with the fissure extending in one-half of the length of the wing, dark cinnamon brown. An oblique stripe of pale yellow or white crosses the basal third of the first lobe, cutting the brown fringe on each side of the lobe. Traces of this stripe are sometimes seen on the second lobe, especially in the fringe on the hind margin. There are also indications of a second stripe on the outer third of the lobes, as shown by a few light scales and the white in the fringes, which are dark elsewhere except on the apical end of the costa. Hind wings and fringes dark brown, with a cluster of black scales in the hind fringe a little beyond the middle, preceded by white, and the fringe at the apex is also white.

I have carefully compared four examples of *californicus*, given me by Lord Walsingham, with seven eastern examples of *lobidactylus* Fitch, and can see no difference except in the ground color, which is considerably lighter in the former; but, as the genitalia are absolutely alike in both, I must consider *californicus* only as a variety. Lord Walsingham doubtfully referred this species to the genus *Aciptilus*, but it seems to me to agree better with the characters of *Trichoptilus*.

Habitat. — Massachusetts, Connecticut, New York, Colorado, California. Food, *Solidago canadensis*.

I have been informed by Mr. Fish that Mr. N. Coleman of Berlin, Conn., has bred this insect from this plant.

GENUS OXYPTILUS Zeller, Isis, Vol. X., p. 765 (1841).

Front smooth, without projection; labial palpi longer than the head, ascending, the second segment with appressed or projecting scales beneath, sometimes forming a short tuft at the apex, terminal segment filiform. Legs long and slim, the anterior and middle tibiæ thickened with scales at the middle and end. Fore wings fissured nearly to the middle, the first lobe narrow, curved somewhat at the end and terminating in a point without a defined anal angle. Second lobe with the apex somewhat produced, and with a more or less prominent anal angle. Feathers of the hind wing narrow and pointed, linear and without anal angles. Vein 2 arises from the median vein, a little before the outer end of the cell, while 3 and 4 arise from a short stalk, 9 and 10 arise one after the other from 8, and 11 arises near 8 from the upper angle of the cell. In the hind wing the costal vein terminates near the outer third of the costa; the continuation of the subcostal runs through the middle of the first feather and ends in the apex. The median vein has three branches the third of which ends in the apex of the second feather. The third feather with a single strong vein through the middle, terminating in the apex. This feather has a cluster of dark scales in the hind fringe beyond the middle. The characters of the male genitalia are represented in Plate VI., figs. 1–8.

Synopsis of the Species.

General color tawny yellow,	*periscelidactylus.*
General color light reddish brown,	*delawaricus.*
General color dull grayish brown,	*ningoris.*
General color dark brown,	*tenuidactylus.*

Oxyptilus periscelidactylus.

Pterophorus periscelidactylus Fitch, N. Y. Rep., Vol. I., p. 843 (1854).
Pterophorus periscelidactylus Riley, Mo. Rep., Vol. I., p. 137 (1869).
Pterophorus periscelidactylus Riley, Am. Ent., Vol. II., p. 234 (1870).
Oxyptilus periscelidactylus Zell., Ent. Zeit., Vol. XXXII., p. 178 (1871).
Pterophorus periscelidactylus Pack., Guide, p. 356 (1872).
Oxyptilus periscelidactylus Zell., Beitr., Part 2, p. 119 (1873).
Pterophorus periscelidactylus Saund., Can. Ent., Vol. V., p. 99 (1873).
Oxyptilus periscelidactylus Wlsm., Pter. Cal. and Ore., p. 25, Pl. II., fig. 5 (1880).
Oxyptilus periscelidactylus Saund., Ins. Inj. Veg., p. 268 (1889).
Oxyptilus periscelidactylus Comst., Manual, p. 238 (1895).
Oxyptilus periscelidactylus Smith, Econ. Ent., p. 318 (1896).

Expanse of wings, 14 to 29 mm. Head, thorax and fore wings tawny yellow. Palpi slim, porrect or ascending, reaching as high as the top of the head, white touched on the outside of second and third segments with tawny yellow. Antennæ dark brown beneath, white above and dotted with white along each side. Posterior part of the thorax marked in some specimens with white on the top of the tegulæ, the sides and two longitudinal stripes on the top of the metathorax. Abdomen tawny yellow, marked more or less imperfectly with a white stripe along each side and also on each side of the dorsal stripe, except on the third segment, which is entirely dark tawny brown. Underside white, striped with tawny brown. Fore legs white, with longitudinal brown lines on the femora and tibiæ; middle and hind femora white, striped with tawny; middle tibiæ tawny on the outside, also a tuft of scales on the middle and at the end tawny; hind tarsi tawny at the middle and end, and all the tarsi are marked more or less with this color at the end of the segments.

Fore wings fissured nearly to the middle, tawny yellow, with two oblique white stripes crossing the lobes, dividing them into nearly equal parts, the space between these stripes often rusty brown, a transverse white spot just within the end of the fissure is edged on its inner side with rusty brown, the posterior end often extending outward and fusing with the first cross line. There is usually a very oblique white spot on the cell near the middle of the wing, with a dark dot at the basal end of it, and a second white spot rests on the hind margin at the basal fourth of the wing. The fringes of the two lobes are whitish, cut by blackish at the apex and anal angle, this latter on the second lobe extending along nearly half the hind border. Hind wings rusty brown, the third feather white in the middle and dark brown at the end, with large dark scales in the fringes on both sides of this part of the feather.

Thirty-five specimens examined.

Habitat. — Maine to Missouri, Ontario, Quebec, Texas. Food, leaves of the grape vine.

Larva. — Length, about 12 mm. Head yellow, with the mouth parts brown. Body pale greenish yellow, deeply constricted between the segments. Each segment has a transverse row of ten moderately sized tubercles, from each of which arises a cluster of from six to twelve long, whitish, diverging hairs, besides which, scattered over the surface, are short hairs which are enlarged at the tip. Legs yellow, long and slender.

Pupa. — Length, 11 mm. Diameter, 2 mm. Front obliquely truncated, with two irregular ridges extending up over the truncate part and along the dorsum on either side of the median line, diverging towards the metathorax, where they terminate in a pair of flattened, sharp-pointed projections, about as high as two-thirds of the diameter of the pupa. The ridges are higher, and toothed on the top of each segment. On the first five abdominal segments there is a row of short spines on each side, in line with the abdominal projections. These spines incline forward, and on the posterior side is a small tooth and two short diverging club-shaped bristles. The pupæ attach themselves by a cluster of fine hooks at the end of the abdomen to a button of silk spun by the caterpillar before pupating. The pupal stage lasts about a week.

So far as I can learn, nothing is known of the egg and early larval stages. Both Fitch and Riley expressed the opinion that there were two generations in a year, but it has not been observed. The moths are on the wing here in Amherst during the latter part of June.

OXYPTILUS DELAWARICUS.

Oxyptilus Delawaricus Zell., Verh. z.-b. Ges. Wien, XXIII., p. 318 (1873).

Oxyptilus delawaricus Wlsm., Pter. Cal. and Ore., p. 29, Pl. II., fig. 7 (1880).

Expanse of wings, 17 to 18 mm. Head, thorax and fore wings light reddish brown. Palpi projecting forward about the length of the head, acuminate, lighter beneath and at the tip, the second segment tufted beneath at the end. Antennæ fuscous, dotted with white above. Abdomen reddish brown at the base, yellowish white beyond and indistinctly marked with whitish scales and lines, but not so conspicuously marked as *tenuidactylus*. Legs white, barred with dark brown.

Fore wings with a few whitish scales scattered along the costa, which is slightly shaded with fuscous beyond the middle. There is a faint brown spot on the cell before the middle, and an indistinct pale spot on the basal fourth of the hind margin. Two oblique white stripes cross the first lobe, dividing it into thirds, the outer stripe appearing again on the second lobe, while only a trace of the inner stripe is occasionally seen on the second lobe, extending along to the inner end of the fissure, which is edged with white and dark brown. The ground color of the lobes is often darker than the rest of the wing. The costal fringe from the outer white stripe to the apex is white, that within the fissure is brown, while the fringe on the rest of the second lobe is white, cut with brown at the apex, and from the anal angle along the hind margin to the middle of the lobe, beyond which in one or two places black scales are seen in the white fringe. Hind wings darker brown than the fore wings, and with the usual cluster of black scales in the fringe, near the apex of the third feather. Nine specimens examined.

Habitat. — Canada, New Hampshire, Massachusetts, California. Early stages and food plant unknown.

OXYPTILUS NINGORIS.

Oxyptilus ningoris Wlsm., Pter. Cal. and Ore., p. 26, Pl. II., fig. 6 (1880).

Expanse of wings, 15 to 20 mm. Head and thorax dark grayish brown. Palpi clothed with close scales, second segment untufted. Antennæ brownish, dotted with white above. Abdomen grayish white at the base, brownish fuscous beyond, with three pairs of slender white streaks diverging from the front to the back of each of the anterior segments; beyond them crossed by lines of whitish scales. Legs white and banded with brownish fuscous.

Fore wings dull grayish brown, sprinkled with whitish scales along the costa, with two oblique white stripes across the lobes and a small white spot at the end of the fissure, connected with the first oblique stripe by the white of the fringes, which beyond this are brownish, except on the outer end of the costa of the first lobe and in the concave outer border of the second lobe, where they are white. There is also an inconspicuous white spot on the basal fourth of the hind margin, and a similar ill-defined spot near the middle of the wing. Hind wings brownish fuscous, the first feather barred with white beneath and the third feather widely barred with white and with blackish scales in the fringe on both sides towards the outer end. Six specimens examined.

Habitat. — California, Oregon. Early stages and food plant unknown.

OXYPTILUS TENUIDACTYLUS.

Pterophorus tenuidactylus Fitch, N. Y. Rep., Vol. I., p. 848 (1854).
Oxyptilus nigrociliatus Zeller, Verh. z.-b. Ges. Wien, XXIII., p. 322 (1873).
Oxyptilus nigrociliatus Wlsm., Pter. Cal. and Ore., p. 31, Plate II., fig. 8 (1880).
Oxyptilus delavaricus Forbes, 3d Ill. Rep., p. 91, Plate X., fig. 2 (1885).
Oxyptilus nigrociliatus Saund., Inj. Ins., p. 314, figs. 326-7 (1889).

Expanse of wings, 12 to 15 mm. Head and thorax dark tawny brown, with a tinge of coppery red; posterior part of the thorax white. Palpi ascending, reaching above the top of the head, slender, not tufted. Antennæ black, dotted with white above. Abdomen of the same color as the wings, with two diverging white lines on the top of the third segment, and the fifth strongly marked with white above except in the middle line. Legs white and banded with dark brown.

Fore wings dark tawny brown, with a tinge of coppery red in certain lights. Two oblique white stripes cross the lobes, the inner one being the wider, and both more or less indistinct or wanting on the second lobe. There is a faint indication of a white spot near the middle of the wing and a similar one at the inner end of the fissure. Fringes white on the apical part of the costa and on the outer margin, cut with blackish at the apex and anal angle of each lobe, and also blackish in the fissure and on the outer part of the hind margin of the second lobe. Hind wings of the same color as the fore wings, with the first feather barred with white beneath and the third feather white in the middle, beyond which the fringe on both sides is thickened by heavy black scales. Fifty-eight specimens examined.

I have before me one specimen from the National Museum, labelled, in Zeller's handwriting, "Oxyptil. nigrociliatus Z., N.

Am." It also has a printed label, "Collection C. V. Riley," and therefore it is probable that this specimen was determined by Zeller himself. I also have two specimens given me by Lord Walsingham which he took in California. Although Professor Zeller declared Lord Walsingham's Californian specimens to be identical with his *nigrociliatus*, yet, because of the lighter color of the Californian specimens, his lordship wrote: "It is open to question how far the two forms may be entitled to be considered distinct; but I must leave it to be decided by some one who has a more extended series of the undoubted *tenuidactylus* to refer to." I have the types of Fitch in my possession, and there are two specimens of *tenuidactylus*, one of which is a male, from which the figures of the genitalia on Plate VI. were drawn. I have carefully compared this with the genitalia of the Californian specimens, as well as other eastern specimens, and find that there is absolutely no difference. There is, therefore, no doubt that Lord Walsingham was correct in considering *nigrociliatus* the same as *tenuidactylus*, and that his Californian specimens are light varieties of the same species. I have a specimen from Philadelphia as light as any of my Californian specimens received from Lord Walsingham, and one taken in South Abington, Mass., which is as light in color as the lightest specimen from California. This, with many others, was taken July 19, 1881, by Mr. J. Elwyn Bates, who found them flying around blackberry bushes in large numbers.

Habitat. — Massachusetts, New York, Delaware, Maryland, West Virginia, Illinois, Ontario, Colorado, California. Food, blackberry. This species has been bred from blackberry by Prof. William Saunders and also by Prof. S. A. Forbes.

"About the middle of June the larva reaches full growth, when it is about four-tenths of an inch long, of a pale greenish-yellow color, streaked with pale yellow, and with transverse rows of shining tubercles, from each of which arise from two to six spreading hairs of a yellowish-green color. The head is small, pale green, with a faint brown dot on each side.

"When the larva is about to change to a chrysalis, it spins a loose web of silk on a leaf or other suitable spot, to which the chrysalis is attached. This is less than three-tenths of an inch long, pointed behind, enlarging gradually towards the front, where, near the end, it slopes abruptly to the tip. Its color is pale green, with a line along the back of a deeper shade, margined on each side with a whitish ridge; it is also more or less hairy. In about a week or ten days the chrysalis changes to a darker color, shortly after which the perfect insect escapes." (Saunders.)

GENUS PLATYPTILIA Hüb., Verz. bek. Schm., p. 429 (1826).

Front with a conical projection, covered by a longer or shorter tuft of scales. Labial palpi long, slim, porrect or slightly ascending, closely scaled, the third segment filiform and shorter than the second. Legs long and slim, the tibiæ with darker scales and sometimes thickened at the end and also in the middle of the hind tibiæ.

Fore wings fissured about one-third of their length, the lobes, especially the second, wider at the outer end than at the base, each with a distinct anal angle, the first falcate and the second convex on the outer margin. The cell is nearly rectangular at the outer end, and veins 5 and 6, as well as the cross vein, are very weak. Two internal veins are present. Vein 2 arises from the outer third of the median vein and ends in or near the anal angle of the second lobe, while vein 3 ends in the middle and 4 in the apex of the same lobe. Vein 7 arises a little below the anterior angle of the cell and ends in or near the anal angle of the first lobe; 8 and 9 are from a stalk which arises from the anterior angle of the cell, and 8 ends in the apex, while 9 ends in the costa; 10 and 11 are somewhat remote from each other and from the stalk of 8 and 9. The first feather of the hind wings has a blunt apex, and is wider towards the outer end than at the base. Veins 7 and 8 arise separately from the base of the wing, approach very near to each other at the basal third and end at the widest part of the feather, one in the costa a little before the apex, and the other in the outer margin behind the apex. The second feather has an acute apex and a distinct anal angle; and vein 3, arising a little before the end of the cell, ends in the anal angle, while 4 arises from the end of the cell and ends in the apex of this feather. The third feather is narrow and tapers gradually to the apex, but there is usually a slight enlargement indicating the anal angle near the middle of the hind margin. A cluster of black scales more or less pronounced occurs in the fringe of the hind margin. One internal vein runs through the middle of this feather and a second terminates at the end of the second fissure.

The characters of the genitalia are represented in plates V., VII. and VIII.

SYNOPSIS OF THE SPECIES.

1.	Palpi and frontal tuft much longer than head,	*marginidactyla.*
	Palpi and frontal tuft not longer than head,	2.
2.	With a dark triangle on the outer third of costa,	3.
	Without a dark triangle on the outer third of costa,	13.
3.	Cluster of dark scales in the middle of fringe of third feather,	4.
	Cluster of dark scales beyond the middle,	10.
4.	Hind tibiæ white, banded with dark near middle and end,	5.
	Hind tibiæ without these characters,	6.
5.	More than half the space between spurs white,	*carduidactyla.*
	Less than half the space between spurs white,	*percnodactyla.*
6.	Ground color of fore wings pale fawn,	7.
	Ground color of fore wings whitish,	8.
7.	Expanse of wings 36 mm.,	*grandis.*
	Expanse of wings 20 mm.,	*fragilis.*
8.	Expanse of wings 30 mm.,	*albidorsella.*
	Expanse of wings 20 mm.,	*shastæ.*
	Expanse of wings 25 mm.,	9.
9.	Costa black between stripes on first lobe,	*orthocarpi.*
	Costa not black between stripes on first lobe,	*albida.*
10.	Fore wings reddish fuscous,	11.
	Fore wings pale gray marked with black,	12.
11	Markings dark brown,	*acanthodactyla.*
	Markings light brown,	*edwardsii.*
12.	Thorax white,	*pica.*
	Thorax gray,	*cosmodactyla.*
13.	First lobe with two light cross lines or stripes,	14.
	First lobe without cross lines or stripes,	15.
14.	Costa cinnamon brown, hind margin white,	*albicans.*
	Fore wings white shaded with brownish scales at base and costa,	*petrodactyla.*
	Fore wings brownish gray,	*tesseradactyla.*
15.	Fore wings cinereous,	*modesta.*
	Fore wings cinnamon brown,	16.
16.	Second segment of palpi enlarged with scales,	*albiciliata.*
	Second segment of palpi not enlarged with scales,	*adusta.*

PLATYPTILIA PICA.

Amblyptilus pica Wlsm., Pter. Cal. and Ore., p. 21, Plate II., fig. 1 (1880).

I have never seen this species, and therefore repeat Lord Walsingham's description: —

"Head and palpi cinereous, dusted with white scales. Antennæ cinereous, faintly dotted with whitish above. The thorax white touched with cinereous above and at the sides, with two black spots behind.

"Fore wings white, dusted with cinereous along their costal half before the fissure; the costa fuscous, dotted with white; a blackish spot before the middle of the wing touching the costal shade; another nearer to the base below it; a blackish fuscous, triangular, costal patch before the fissure, followed by a conspicuous white space, beyond which is a fuscous shade, crossing both lobes, divided by a white line running parallel to the apical margin, on which the cilia are white, dotted with some fuscous. The dorsal half of the wing is less shaded or dusted than the costal, and contains two short, oblique, blackish dashes near the middle, the second being followed by a straight streak of brownish fuscous scales running parallel to the dorsal margin. The cilia on the dorsal margin are white, with two distinct tooth-like tufts of black scales; the cilia within the fissure are fuscous.

"Hind wings fuscous brown, with cilia of all the lobes the same color, except on the dorsal margin of the third, where they are white, irrorated with black scales along the basal half, and bearing a conspicuous projecting triangular tuft of black scales beyond the middle, and a few more below the apex of the lobe.

"The abdomen is white above and beneath, with a fuscous line along each side, which also crosses it above near the base, and again below the middle. The third pair of legs are annulated with white and fuscous brown, the bases of the white spurs being also fuscous. Expanse, 23 mm.

"It is allied to *A. acanthodactylus* and *A. cosmodactylus* of Huebner."

Habitat. — California. Early stages and food plant unknown.

PLATYPTILIA COSMODACTYLA.

Alucita Cosmodactyla Hüb., Aluc., Plate VII., figs. 35, 36 (1825).
Amblyptilus cosmodactylus Wlsm., Pter. Cal. and Ore., p. 23, Plate II., figs. 2–4 (1880).

Expanse of wings, 18–21 mm. Head, thorax and fore wings pale gray, finely striated with black; a triangular black spot on the outer third of the costa, followed by a small white costal spot, which is in turn followed by a broad black band edged on the outside with white, which crosses the lobes diagonally. On the second lobe the white cuts a dark basal portion twice at equal distances; costa of the wing dark gray with a series of white dots. Fringes blackish basally, white externally. Hind wings dark grayish brown, with a large cluster of black scales beyond the middle of the fringe of the third feather, and a small black cluster on the apex.

Habitat.— Europe, California, Oregon. Food, *Stachys*, *Aquilegia*, *Geranium*, *Orthocarpus*. "Larva, from pale green to purplish pink; dorsal line dark gray; subdorsal white, conspicuous; lateral and spiracular whitish, interrupted; head dark reddish fuscous, almost black." (Meyrick.)

PLATYPTILIA ACANTHODACTYLA.

Alucita Acanthodactyla Hüb., Aluc., Plate V., figs. 23, 24 (1825).

Expanse of wings, 18–21 mm. Head, thorax and fore wings reddish fuscous, marked very similarly to *cosmodactyla*, but may be separated by the ground color of the fore wings.

Habitat. — Europe, South Africa, New York. Food, *Stachys*, *Mentha*, *Ononis*, *Calamintha*, *Pelargonium* and *Euphrasia*.

I have a single specimen of this species, taken at West Farms, N. Y., by Mr. James Angus.

"Larva, from pale green to deep purple; dorsal line dark gray; subdorsal, lateral, and sometimes spiracular whitish, interrupted; head yellowish gray or yellowish brown, blackish-marked." (Meyrick.)

PLATYPTILIA EDWARDSII.

Platyptilus Edwardsii Fish, Can. Ent., Vol. XIII., p. 72 (1881).

Expanse of wings, 22–27 mm. Head and thorax ochreous brown; frontal tuft short and blunt, brown above, whitish beneath. Palpi ascending, extending beyond the frontal tuft; antennæ finely ciliated, dotted above with dark scales, cinereous beneath. Abdomen ochreous, slender. Legs ochreous brown, hind tibiæ and all the tarsi paler.

Fore wings reddish brown, darker on the costa; triangular costal spot dark brown, bordered on the outside by whitish scales. A small brown spot occurs near the hind margin at the basal fourth, another near the costa at the basal third, and a transverse white line at the apical third of the lobe. The first lobe with a dark longitudinal spot half way between the costa and hind margin; second lobe dark at the anal angle. Fringes whitish, with a patch of dark scales before and another just behind the apex of the costal triangle. Hind wings reddish brown; fringes brown, whitish at base of hind margin and bearing a small patch of dark scales just before the apex.

Habitat. — Maine, Massachusetts. Early stages and food plant unknown.

PLATYPTILIA CARDUIDACTYLA.

Pterophorus carduidactylus Riley, Mo. Rep., Vol. I., p. 180, Plate II., figs. 13, 14 (1869).
Platyptilus cardui Zell., Stett. Ent. Zeit., Vol XXXII., p. 179 (1871).
Platyptilia cardui Zell., Beitr., p. 118 (1873).
Platyptilus cardui Wlsm., Pter. Cal. and Ore., p. 7, Plate I., fig. 6 (1880).
Platyptilus cardui Riley, Gen. Index Ent. Rep. Mo., p. 83 (1881).

Expanse of wings, 23 mm. Head, thorax and abdomen tawny yellow. Legs tawny yellow, except the tarsi, which are nearly white, spotted with dark brown; spurs brown, with darker tips.

Fore wings tawny yellow, fissure extending in about one-fourth of the length of the wing; triangular spot dark brown, its outer margin slightly concave; three dark diffuse longitudinal spots, one on the basal third of the wing near the costa, one near the hind margin, nearer the base than the latter, and one on the outer third of the hind margin. Two paler transverse lines cross the outer portion of the wing, one bordering the triangular spot behind and curving across the lower lobe towards the anal angle, the other very near and parallel to the outer margin. The space between these two lines usually darker than the ground color. Fringes dark basally, whitish outwardly except three brown patches of scales, one in the middle of hind margin, one on the anal angle and a smaller one half-way between. Hind wings ashy brown. Fringes concolorous, with a patch of very dark scales about half way on hind margin of third feather, and a few scattering scales about half-way between that and the base.

Habitat. — New York, Pennsylvania, Illinois, Missouri, Texas, California, Washington. Food, Thistle (*Cirsium lanceolatum*).

"*Larva.* — Average length, 0.60. Largest in the middle of the body, tapering thence each way. Color light straw yellow, greener when young. Somewhat darker, partly translucent, dorsal, subdorsal, and stigmatal lines. Two lateral rows of black spots, the lower spots rather smaller and placed behind the upper ones. A third row above these, and others along the back, but so small that they are generally imperceptible with the naked eye, except on the thoracic segments, being especially distinct on segment 2. Head small, black, sometimes inclining to brown. Cervical shield black, divided longitudinally in the middle by a lighter line. Caudal plate also black. Segment 11, besides the spots above mentioned, has two transverse black marks, the posterior one the largest. Thoracic legs black, the others of the same color as the body.

"*Pupa.* — Average length, 0.45. Soft, dull yellow, with a lateral dusky line each side of dorsum, and another, less distinct, each side of venter. Also dusky about the head and wing-sheaths." (Riley.)

PLATYPTILIA PERCNODACTYLA.

Platyptilus percnodactylus Wlsm., Pter. Cal. and Ore., p. 8, Plate I., fig. 7 (1880).

Expanse of wings, 22 mm. Head and thorax pale brown; antennæ spotted on the upper side with white and brown. Abdomen brownish, paler at the base. Legs whitish, slender, slightly enlarged, and tinged with brownish at the end of the segments. Spurs pale.

Fore wings pale brown with much paler blotches, one reaching from the base of the fissure to the costa, another below the dark-brown costal triangle and another at the base of the costal margin; a pale streak crosses the wing, parallel to the outer margin, which is brownish; a brown line at the base of the fringes, which are brown except within the fissure and near the anal angle; a few brown scales near the middle of the hind margin. Hind wings brown, the third feather paler than the others, and with a few fuscous scales in the fringe of the hind margin of the third feather.

Habitat. — California. Early stages and food plant unknown.

PLATYPTILIA SHASTÆ.

Platyptilus shastæ Wlsm., Pter. Cal. and Ore., p. 14, Plate I., fig. 11 (1880).

As I have no example of this species, I quote Lord Walsingham's description: —

"Head white; palpi white, touched with cinereous at the sides; antennæ dotted above. Thorax dusted with cinereous.

"Fore wings narrow, whitish, dusted with cinereous atoms, especially along the costa; the triangular costal patch brown, followed by the usual pale space; a brown line along the base of the white fringes; a very slender whitish line, running parallel to the apical margin, terminates in a white dash on the costa, reaching to the extreme apex; the antemedian dots scarcely indicated. Hind wings pale cinereous, the third lobe perhaps slightly the lightest in color; fringes nearly unicolorous, pale cinereous, scarcely paler at their bases. Abdomen yellowish white. The third pair of legs cinereous, slightly whitish below each joint and on the spurs and feet. Expanse 20 mm."

Habitat. — California.

"This species may be distinguished by its slender appearance and narrow fore wings, which are so delicately dusted as to be of almost the same shade as the pale cinereous hind wings, which separate it at once from any of its allies now described."

PLATYPTILIA FRAGILIS.

Platyptilus fragilis Wlsm., Pter. Cal. and Ore., p. 16, Plate I., fig. 12 (1880).

Expanse of wings, 19 mm. Head and thorax white, sprinkled with yellowish scales; palpi slightly cinereous; abdomen yellowish; legs yellowish white, brownish at the joints.

Fore wings fawn color with yellowish tinge; the two antemedian spots and the triangular costal patch brown; outer margin brownish. Fringe white with a fine brown line at its base. Two brown dashes in the fringes of the hind margin before the anal angle. Hind wings very pale brownish white with paler fringes.

Habitat. — California. Early stages and food plant unknown.

PLATYPTILIA ORTHOCARPI.

Platyptilus orthocarpi Wlsm., Pter. Cal. and Ore., p. 11, Plate I., fig. 9 (1880).

Expanse of wings, 25 mm. Head and thorax whitish, slightly tinged with ochreous; frontal tuft short. Hind legs whitish, marked with fuscous on the outside, with white annulations below each segment; spurs and feet white.

Fore wings dusted with ochreous and brown scales, especially on the costa; triangular costal patch and a dash at the end of the first third of the wing very dark fuscous, and more produced toward the apex than in *albida;* space beyond the triangular patch and a streak parallel to the outer margin white, with the space between them brown. Hind wings fuscous brown; fringes fuscous with a white line at the base.

Habitat. — Oregon. Food, *Orthocarpus.*

PLATYPTILIA ALBIDA.

Platyptilus albidus Wlsm., Pter. Cal. and Ore., p. 10, Plate I., fig. 8 (1880).

Expanse of wings, 24 mm. Head and thorax white, with a bluish tinge. Antennæ white dotted with brown above. Abdomen white streaked with fuscous. Hind legs dark ashy in color; spurs and feet slightly paler on the inner side.

Fore wings bluish white, with brownish scales, especially along the costa to the brown triangular spot, beyond which is a pale stripe running parallel to the outer margin across both lobes of the wing; another pale line near the outer margin; the space between these pale lines is grayish brown except near the costa, where it is brownish; a brown stripe between this and the fringes. Two indistinct brown spots on the inner half of the wing, the lower one much nearer the base than the upper one; a brown line at the base of the fringe, which is white except at the anal angle. Hind wings brown; fringes brown, a little paler on the hind margin of the third feather.

Habitat. — Southern Oregon, California. Early stages and food plant unknown.

PLATYPTILIA ALBIDORSELLA.

Platyptilus albidorsellus Wlsm., Pter. Cal. and Ore., p. 13, Plate I., fig. 10 (1880).

Expanse of wings, 30 mm. Head and thorax white, with a few scattered fuscous scales; frontal tuft short. Legs whitish tinged with cinereous; feet and spurs paler.

Fore wings white, thickly sprinkled with brown, forming a widening streak from the base of the wing to the triangular patch, beyond which it is paler and crossed by a white costal patch and a white line near the outer margin and parallel to it. Fringes ashy, with a brown line at the base. Hind wings white, thickly dusted with brown. Fringes paler brown, much paler at the base.

Habitat. — California. Early stages and food plant unknown.

PLATYPTILIA GRANDIS.

Platyptilus grandis Wlsm., Pter. Cal. and Ore., p. 6, Plate I., fig. 5 (1880).

Expanse of wings, 36 mm. Head and thorax pale fawn color; antennæ brownish fawn color, spotted with white above; frontal tuft fawn color, shorter than in allied species. Legs very pale, the hind tibiæ with their extremities darker.

Fore wings pale fawn color, with the costa and triangular blotch fuscous; two brownish, elongated dots near the middle of the wing, the larger one nearer the base. The lobes are crossed by a pale wavy streak parallel and near to the outer margin; a brown line at the base of the fringes, which are dark fuscous except near the anal angle, where they are pale. Hind wings brownish fawn color. Fringes pale except on the hind margin of the third feather, where they are brownish.

Habitat. — California. Early stages and food plant unknown.

PLATYPTILIA MODESTA.

Platyptilus modestus Wlsm., Pter. Cal. and Ore., p. 18, Plate I., fig. 14 (1880).

As I have no example of this species, I give a copy of Lord Walsingham's description: —

"Head and palpi cinereous; antennæ slightly dotted above.

"Fore wings very narrow, cinereous, with a slight ochreous tinge towards the dorsal margin. The costa sprinkled and shaded with fuscous, the fuscous shade widening towards the fissure, forming an elongate but indistinct triangular costal blotch. The apical portion of the wing more or less shaded with fuscous, and a fuscous line along the base of the cilia on the apical margin, which are whitish at their points. The cilia within the fissure and those along the dorsal margin before the anal angle white, the latter containing a few dark scales. Hind wings cinereous; the cilia slightly paler, especially along their bases. Posterior legs cinereous; the feet slightly paler. Expanse 22 mm."

Habitat. — California. Early stages and food plant unknown.

PLATYPTILIA PETRODACTYLA.

Pterophorus petrodactylus Walk., Cat. Lep. Het., Vol. XXX., pp. 940, 941 (1864).

Platyptilus petrodactylus Wlsm., Pter. Cal. and Ore., p. 20, Plate II., fig. 15 (1880).

Expanse of wings, 23 mm. Head, thorax and abdomen shaded cinereous. Legs cinereous, slightly thickened at the joints; the spurs apparently of equal length.

Fore wings white, shaded with cinereous or ashy brown; costa brownish beyond the middle; an oblique brownish fuscous line, starting from the costa before the apex, extends inward more obliquely than the outer margin, but does not reach the fissure. This line is widest on the costa, tapering to a point inwardly, and is darker at its lower end. Fringes white within the fissure, with a cinereous line near their bases, shaded with fuscous at the anal angle. Hind wings pale cinereous; fringes slightly darker towards the end of the feathers.

Habitat. — Arctic America. Early stages and food plant unknown.

PLATYPTILIA ADUSTA.

Platyptilus adustus Wlsm., Pter. Cal. and Ore., p. 5, Plate I., fig. 4 (1880).

Expanse of wings, 23 mm. Head, frontal tuft, thorax and abdomen fawn color, with a brownish tinge. Legs pale fawn color, with the feet and anterior parts of the tibiæ slightly paler.

Fore wings fawn color, somewhat streaked with a paler tint; the costa much darker. Fringes but little paler than the wings, but with a fine brown basal line. Hind wings fawn color, the first and second feathers slightly darker than the fore wings.

Habitat. — California. Early stages and food plant unknown.

PLATYPTILIA ALBICILIATA.

Platyptilus albiciliatus Wlsm., Pter. Cal. and Ore., p. 17, Plate I., fig. 13 (1880).

Expanse of wings, 24 mm. Head cinnamon brown; frontal tuft short. Thorax grayish brown. Hind legs cinereous; feet and spurs paler.

Fore wings cinnamon brown, with a slight grayish tinge on the costa and outer margin. Fringes whitish except at the base, where they are of the same color as the wing. Hind wings pale brown, with the fringes paler at the base.

Habitat. — California. Early stages and food plant unknown.

PLATYPTILIA ALBICANS.

Platyptilia albicans Fish, Can. Ent., Vol. XIII., p. 71 (1881).

Expanse of wings, 22 mm. Head and thorax cream color, frontal tuft short and blunt. Palpi extending beyond frontal tuft, slightly ascending. Antennæ cinnamon brown, dotted above with white. Abdomen ochreous, lighter at base. Legs whitish, anterior and middle femora and tibiæ cinnamon brown, sprinkled with whitish scales; tarsi cinereous, first two segments whitish interiorly; posterior tibiæ cream color, brownish just before the spurs.

Fore wings creamy white along the hind margin, on the costa cinnamon brown; costal triangular spot cinnamon brown, bordered outwardly above the fissure by a broad white line; below the fissure its apex is continuous with the brownish color of the second lobe. Both lobes cinnamon brown, with a transverse white line not reaching the hind margin of the second lobe. Fringes cream color, sprinkled with cinnamon brown. Hind wings cinnamon brown, with fringes concolorous.

Habitat. — Nevada. Early stages and food plant unknown.

PLATYPTILIA TESSERADACTYLA.

Alucita tesseradactyla Linn., Fn. Suec., p. 370 (1761).

Expanse of wings, 16–20 mm. Head, palpi and frontal tuft grayish brown. Antennæ whitish, dotted above with dark brown. Thorax gray in front, white behind.

Fore wings whitish, heavily dusted with brownish gray. The somewhat indistinct brownish triangle on the outer third of the costa is followed by a whitish spot, and a subterminal white line crosses both lobes.

Habitat. — Europe, Massachusetts. Food, *Gnaphalium dioicum*, *G. arenarium*.

"The egg is pale green, smooth and somewhat elongated, and the larva in its earliest stage is clear white with isolated hairs. Head, thoracic and anal shields black. Later (in September) the dorsal and lateral rows of rust-brown points appear, and in March, after hibernating, it becomes stout without increasing very much in length. The head, thoracic and anal shields are dark brown; dorsal stripe is crimson rust color; the subdorsal and lateral lines are of the same color but finer. The ground color of the body is yellowish above and rust red beneath. The adult larva is a little smaller at each end and cylindrical in the middle. The head is small and black, the thoracic shields small, black divided by a light line. The color of the body is dark ferruginous brown. On the back stand whitish flecks with two pairs of black tubercles on each segment, of which the hinder are placed farther from each other than those in front; similar tubercles occur on the sides, from which arise long light hairs. The anal shield and legs are dark brown. These larvæ frequently vary in the tone of the color." (Gartner.)

Platyptilia marginidactyla.

Pterophorus marginidactylus Fitch, N. Y. Rep., Vol. I., p. 848 (1854).
Pterophorus nebulædactylus Fitch, N. Y. Rep., Vol. I., p. 849 (1854).
Platyptilus Bertrami Roessl., Wien. Mts., Vol. VIII., p. 54 (1864).
Platyptilus Bischoffii Zell., Stett. Ent. Zeit., Vol. XXVIII., p. 333 (1867).
Platyptilia Bertrami Zell., Stett. Ent. Zeit., Vol. XXXIV., p. 135 (1873).
Platyptilia Bischoffii Zell., Verh. z.- b. Ges., p. 317 (1873).
Pterophorus cervinidactylus Pack., Ann. Lyc. N. Y., Vol. X., p. 266 (1873).
Platyptilus bertrami Wlsm., Pter. Cal. and Ore., p. 3., Plate I., fig. 3 (1880).
Platyptilia bertrami Tutt, Mon., p. 31 (1891).
Platyptilia Bertrami Mey., Brit. Lep., p. 434 (1895).
Platyptilia Bertrami Hof., Deut. Pter., p. 55 (1895).

Expanse of wings, 22–28 mm. Head, palpi, frontal tuft, thorax and abdomen pale ochre yellow, the collar and outside of the palpi sometimes a little darker. Palpi and frontal tuft of nearly equal length, extending forward of the head a distance equal to the length of the head. Antennæ whitish, dotted above with dark brown. All the coxæ, femora, anterior and middle tibiæ brownish yellow on the outside, whitish within. Hind tibiæ whitish at the base, dull brown on the outer half. All the tarsi whitish, except in some examples the segments of the hind tarsi are touched with dull brown. Fore wings somewhat falcate at the end of the first lobe, pale ochre yellow, fuscous along the costal edge, broken by an oblique light shade above and a little beyond the end of the fissure, within which a darker shade extends from the costa across the cell containing two brownish dots, one on each angle of the cell. The anterior dot is seldom present and often both are absent. An elongated ochre yellow spot rests on the cell halfway between the discal dots and the base of the wing, a second elongated spot on the hind margin at the base and another near the middle of the wing. The lobes are somewhat darker at the outer end, sometimes with an indication of a pale subterminal line. Fringes whitish, with a darker shade outwardly, and with a dark-brown basal line which extends a little into the fissure. The darker ochre yellow spots are often extended so that nearly the whole surface of the wing is of this color. Hind wings dark ochreous fuscous, with a more or less distinct cluster of dark scales near the middle of the hind fringe of the third feather.

The genitalia are represented on Plate III., figs. 4 and 5. For the sake of comparison the genitalia of *P. ochrodactyla* are represented on the same plate, figs. 14 and 15. These were made from specimens received from Professor Zeller, and labelled in his own handwriting.

The above description was drawn up from one hundred and thirteen American specimens.

Habitat. — Europe; Canada, Maine, New Hampshire, Massachusetts, New York, Pennsylvania, Colorado, California, Oregon. Food, Yarrow (*Achillea millefolium*).

In some unpublished notes received from Mr. Charles Fish, I find the following statement: "Received from Mr. J. Elwyn Bates, on June 30, 1881, some eggs of *Plat. bischoffii*, which were laid June 24, to the number of twenty-four. They were elliptical in outline and somewhat flattened. The longer diameter was three-sevenths of a millimeter and the shorter diameter was three-tenths of a millimeter, and the surface was irregularly corrugated. When first deposited they were of a light cream color or almost hyaline with a glossy surface, but after two days they turned to a deep flesh color." There was no note made as to whether these eggs hatched, or not.

Different stages of the larva have been described by several writers in Europe, and the mature larva is briefly described as follows: "Larva green; dorsal line darker or somewhat brownish tinged; subdorsal and lateral gray whitish; subspiracular white; head whitish yellowish." (Meyrick.)

"The pupa is a little over half an inch long, with a longish beak in front, projecting at a slight angle downwards from the head; pointed at the tail; the wing cases of moderate length, well developed, and the ends of the leg cases projecting free from the abdomen. The color is bright pale green, dorsal line dark green, edged on the thorax with white; beak white above, rust color on the sides; there is a conspicuous streak on this rust color on the hind part of the thorax, and the same color also appears (but more faintly) on the abdominal point and at the tip of the leg cases; subdorsal line dark green, lateral line white. Ventral surface pale green, with darker green lines, and the wing-cases with whitish rays." (Porritt.)

The insects before me, so far as the labels indicate, were on the wing in Maine, June 24; Massachusetts, from the 10th to the 27th of June; New York, from June 23 to July 17; Missouri, in May; Colorado, from the 11th to the 16th of June; California, June 1 to 18.

I have seven European species of *Platyptilia* in my collection, all named by Professor Zeller. Five of these are males, and an examination of the genitalia proves that one which Zeller named *bertrami* is *ochrodactyla* and one named *ochrodactyla* is *bertrami*. They approach each other so closely in form and coloration that it is not surprising that they should have been considered conspecific for so long a time, and that there should have been so much discussion about the matter in the European journals. Mr. Tutt has given an excellent resumé of this discussion in his "Monograph of the Pterophorina of Britain." Mr. Tutt suggests that Haworth's *pallidactyla* is identical with *bertrami*, and in that case it should take precedence, but until this is adopted we must accept the name *marginidactyla* Fitch, which is ten years older than *bertrami*.

The types of Fitch now belong to my collections; and I have made a critical examination of the genitalia, and they agree perfectly with the genitalia of *bertrami*.

GENUS ALUCITA Linn., Syst. Nat., Ed. 10, p. 542 (1758).

Vertex smooth; front smooth or a little swollen, closely scaled; antennæ with a thickened basal segment. Palpi slim, porrect or somewhat ascending, the third segment shorter than the second, pointed and sometimes bent down a little. Anterior and middle tibiæ very slightly thickened at the end; hind tibiæ without thickening of scales. Abdomen moderately slim, the second and third segments not much longer than the others. Fore wings fissured half their length or a little more, the lobes running to a point and bent backward somewhat, especially the second lobe. Feathers of the hind wings all of the same form, linear and pointed, without a cluster of dark scales in the fringe of the third feather.

SYNOPSIS OF THE SPECIES.

Ground color of fore wings gray, ... *belfragei.*
Ground color of fore wings white, ... *montana.*
Ground color of fore wings yellowish white, . . . *cinerascens.*

ALUCITA BELFRAGEI.

Aciptilus Belfragei Fish, Can. Ent., Vol. XIII., p. 142 (1881).

Expanse of wings, 18 mm. Head brownish gray. Palpi brown above, whitish beneath. Antennæ whitish, dotted with pale brown above. Thorax pale ochreous gray in front; hind portion and abdomen pale grayish ochreous, striped longitudinally with fine white lines and marked with dark streaks. Legs pale grayish; fore and middle femora striped longitudinally with whitish and dark brown lines; tarsi pale ochreous, with shadings on the outer side; hind tibiæ and tarsi pale ochreous; spurs tipped with brown.

Fore wings pale ochreous gray, dusted with brown scales; an oblique dark-brown patch at the base of the fissure, bordered posteriorly with white; a small brown spot midway between this and the base of the wing; two longitudinal brown spots on the outer third of the costa of first lobe and one or two brown dots on the outer margin of the same lobe near the apex. Fringes pale brown except at the apex of the second lobe, where they are white. Hind wings brownish cinereous. Fringes pale brown.

Habitat. — Texas. Early stages and food plant unknown.

ALUCITA MONTANA.

Aciptilus montanus Wlsm., Pter. Cal. and Ore., p. 59, Plate III., fig. 14 (1880).

Expanse of wings, 16 mm. Head white, antennæ faintly dotted above with brownish. Thorax, abdomen and legs snow white; the fore and middle legs brownish on the inner side.

Fore wings snow white, sprinkled with ferruginous-brown scales, especially on the outer half of the costa; a spot of these scales before the base of the fissure runs obliquely to a darker spot on the costa, and this is nearly connected by a dark shade with another brown costal spot near the apex; a dark-brown fine streak on the outer half of the costa of the second lobe extends through the fringe under the apex; all of the rest of the fringe is snow white. Hind wings dusted with cinereous brown.

Habitat. — California, New York.

"The larva feeds upon different species of *Solidago*. The first examples were noticed on May 30. At this time they were found only on the under side of the leaves, later they occur on the upper as well. As a rule, they lie close to and parallel with the midvein. At least while young they eat out the parenchyma, leaving the epidermis.

"May 30 the larvæ were .1 of an inch and less in length; entirely white, except claws and mandibles. The body is not flattened at this stage. The first ring is broad, and the head may be well withdrawn into it. The tubercular hairs are spined, plainly seen under a moderate magnifying power.

"June 3 the largest had evidently moulted, length then .2 of an inch; pale green, eighth and ninth rings yellow. Lateral tufts more conspicuous. Dorsal line faint. Subsequent changes not noted until full-grown larva was described the latter part of June. Length .34 to .4 of an inch. Pale pea green, head paler; dorsal stripe of three white lines, the middle one the finest and most clearly defined. The seventh, eighth and ninth rings yellow. The posterior subdorsal papilla of the body rings bears two unequal hairs, the anterior but one; above the spiracles and in front of them also is a papilla; below the same there are two, from which arise long hairs, five from posterior and ten or twelve from anterior, these are spread out fan-like; below these a prominent longitudinal fold. From the first ring proceed long hairs reaching over and beyond the head. Hairs all unbranched and plumose. The body is considerably flattened, so when looking down upon it the spiracles from either side may be seen at once, spiracles conical, rings black.

"The *pupa* is .3 of an inch in length; light green, some of them have a reddish stripe along dorsal part of the abdomen, the conical spiracles of such have the same hue. The upper part of the rings well clothed, especially at extremities and along the lateral ridges. Pupa fastens to a tuft of silk by means of the hooks of the last ring. Moth appears through greater part of July." (Kellicott.)

ALUCITA CINERASCENS.

Aciptilus cinerascens Wlsm., Pter. Cal. and Ore., p. 57, Plate III., fig. 13 (1880).

Expanse of wings, 19 mm. Head slightly ochreous; palpi very short; antennæ pubescent, pale ochreous. Thorax whitish, especially in front, where two indistinct dark lines run forward to the head. Abdomen pale ochreous. Legs whitish, the fore and middle pairs tinged with brown on the inner side.

Fore wings very pale ochreous, dusted thickly with brownish, forming a large spot before the base of the fissure; a subcostal spot before the middle and two small costal spots on the outer half of the first lobe. Fringes below the apex of first lobe and on the apex of the second lobe dark brown; pale subochreous within the fissure, with a brownish spot on the hind margin. Hind wings and fringes pale cinereous; under side pale brownish.

Habitat — California. Early stages and food plant unknown.

GENUS PTEROPHORUS Geoff., Hist. Ins., Vol. II., p. 90 (1764).

Vertex and front smooth; palpi short, not reaching beyond the head or but very slightly; porrect, or slightly ascending, the third segment short and sometimes bent down a little; antennæ with a thickened basal segment. Anterior and middle tibiæ only slightly thickened at the end; hind tibiæ without a thickening of scales.

Fore wings fissured about one-third of their length; both lobes pointed, the hind lobe in some species with a scarcely perceptible anal angle. Feathers of the hind wings unlike in form, with long fringes and without a black scale cluster. The upper angle of the cell is very acute, formed by the very oblique cross vein.

SYNOPSIS OF THE SPECIES.

1.	Ground color of the fore wings snow white,	2.
	Ground color of the fore wings pale sulphur yellow,	*sulphureodactylus.*
	Ground color of the fore wings pale straw color,	4.
	Ground color of the fore wings cream white,	5.
	Ground color of the fore wings very pale brownish gray,	6.
	Ground color of the fore wings ochre yellow,	7.
	Ground color of the fore wings brown or dark gray,	13.
2.	Expanse of wings less than 21 mm.,	*fishii.*
	Expanse of wings more than 21 mm.,	3.
3.	Expanse of wings between 23 and 25 mm.,	*elliottii.*
	Expanse of wings more than 25 mm.,	*homodactylus.*
4.	Costa of first lobe of fore wing indistinctly brownish,	*stramineus.*
	Costa of first lobe of fore wing not marked with brown,	*angustus.*
5.	Expanse of wings 24 mm.,	*helianthi.*
	Expanse of wings 28 mm.,	*lacteodactylus.*
6.	Fore wings with a brown spot at the end of the fissure,	*paleaceus.*
	Fore wings unspotted,	*inconditus.*
7.	With three or four terminal brown spots on outer margin of second lobe,	*kellicottii.*
	Without this character,	8.
8.	Pale ochre yellow without any markings,	*grandis.*
	With more or less markings,	9.
9.	An oblique reddish brown shade from costa to fissural spot,	*cretidactylus.*
	Without this character,	10.
10.	Second lobe of a brighter yellow than the rest of the wing,	*baroni.*
	Without this character,	11.
11.	A brown costal streak over the end of fissure,	12.
	Without this character,	*guttatus.*
12.	Expanse of wings 28 mm.,	*cineraceus.*
	Expanse of wings 22 mm.,	*gratiosus.*
13.	With tuft of scales near middle of hind tibiæ,	*monodactylus.*
	Without this character,	14.
14.	Expanse of wings less than 20 mm.,	*inquinatus.*
	Expanse of wings more than 20 mm.,	15.
15.	Costal region light yellowish brown,	*eupatorii.*
	Costal region dark,	16.
16.	Outer fourth of costa mostly white,	*grisescens.*
	Outer fourth of costa with but little white,	*lugubris.*

PTEROPHORUS FISHII.

Alucita fishii Fern., Can. Ent., Vol. XXV., p. 95 (1893).

Expanse of wings, 20 mm. Thorax and abdomen white. Legs white slightly tinged with brownish.

Fore wings white with a few brown scales scattered over the costal portion before the fissure, forming a faint costal triangular patch, beyond which are two equidistant brown spots on the costa. Fringes pure white. Hind wings and fringes pure white. Described from one specimen with the head wanting.

Habitat. — Nevada. Early stages and food plant unknown.

PTEROPHORUS HOMODACTYLUS.

Pterophorus homodactylus Walk., Cat. Lep. Het., Vol. XXX., p. 941 (1864).

? *Leioptilus hololeucos* Zell., Lep. Westk. Am., p. 23 (1874).

Lioptilus homodactylus Wlsm., Pter. Cal. and Ore., p. 50, Plate III., figs. 8, 9 (1880).

Expanse of wings, 22–27 mm. Head white, palpi and antennæ whitish. Thorax and abdomen white. Legs white, slightly tinged with cinereous.

Fore wings white, very slightly dusted on the costa with brownish scales; a brownish spot before and slightly below the base of the fissure; a group of indistinct brownish scales between this and the base of the wing; a faint indication of two brownish dots on the outer margin. Hind wings and fringes pure white, with a silky lustre. In some specimens the brownish spots are absent.

A variety of this species has the head brown behind and in front, the palpi brownish and antennæ dingy white. Fore wings more heavily dusted with brown scales, fringes tinged at the tips around the obsolete anal angle with pale cinereous. Hind wings and fringes very pale cinereous. Legs white, first two pairs touched with brownish on their inner sides.

A specimen of this species was sent by Lord Walsingham to Professor Zeller, who remarked: "Only larger, otherwise agreeing with *Lioptilus hololeucos* Zeller; on the right anterior wings it has also two dots."

Habitat. — South America, California, Oregon. Food, *Solidago*, *Eupatorium purpureum*.

"*Larva.* — Length, .55 of an inch; pale yellowish green; dorsal line sharply defined, white; subdorsal and stigmatal lines similar; the top of each ring from the second to the tenth bears a minute circle of white interrupting the dorsal line. The dorsal spaces of each ring from the fourth to the eleventh bear a pair of tubercles on either side of the middle line, from these proceed rather long, stiff, hoary, smooth hairs; the thoracic and terminal rings have a single papilla in place of the pairs. These tubercles stand in a light stripe. Below them a single tubercle with similar appendages; below the spiracles a larger one with a minute one back of it bearing three or four hairs, also one above the line of the feet. Legs and ventral surface hairy. The anterior half of the first ring bears many hairs, which hang over the head somewhat. Spiracles round, rim white; back of each there is a short, stiff hair. Head almost colorless, except mouth organs and ocelli; epicranial suture deep; cranial lobes hemispherical, with scattered hairs.

"The pupa measures .45 of an inch. It is light pea green, turning white before the moth escapes. There is a clear dorsal space with an interrupted white line in the middle; also white lines on the lateral faces. The tubercles are set with hairs exactly as in the larva, so the pupa is quite conspicuously clothed; the head and thorax support shorter hairs arising singly from the surface; short, dusky hairs stand in rows on the wing covers, apparently outlining the veins; there is a similar row on the antennæ covers. The pointed cremaster ends with many hooklets, which fasten the pupa securely to the leaf, on which a tuft of silk has been spun by the larva. The thorax is quite obliquely truncated; seen from below, it is slightly bilobed, rendered so by the prominent origin of the antennæ covers; between the lobes there is a slight tufted tubercle." (Kellicott.)

PTEROPHORUS ELLIOTTII.

Alucita elliottii Fern., Can. Ent., Vol. XXV., p. 95 (1893).

Expanse of wings, 23–25 mm. Head very pale fuscous. Thorax and abdomen whitish fuscous. Legs white.

Fore wings white, tinged more or less with ochre yellow near the base and on the apical third of the costa; a very oblique streak of brown scales on the costa near the apex and a dark-brown spot before the fissure; a streak of irregular brown scales extends from the base of the wing to the fissure. Fringes white. Hind wings pure white, with a few ochre yellow scales scattered over the surface in some specimens. Fringes white.

Habitat. — New York. Early stages and food plant unknown.

PTEROPHORUS SUBOCHRACEUS.

Lioptilus subochraceus Wlsm., Pter. Cal. and Ore., p. 53, Plate III., fig. 10 (1880).

? *Pterophorus lacteodactylus* Cham., Can. Ent., Vol. V., p. 73 (1873).

Having no example of this species from California, I copy Lord Walsingham's description: —

"Head whitish above; face and neck brownish; palpi very short, not projecting as far as the front of the head; antennæ whitish ochreous, with the basal joint brown.

"Fore wings pale subochreous, without spots or markings, except a rather oblique delicate ferruginous shade above the base of the fissure, reaching the costa before the apex; the cilia about the dorsal margin of the second lobe are slightly tinged with brownish. Hind wings very pale brownish straw color. Legs whitish.

"Expanse, 28 mm."

Habitat. — California. Early stages and food plant unknown.

I have the type of *lacteodactylus* before me, and the head and palpi agree perfectly with the above description, but the wings are somewhat worn. Without seeing an authentic specimen of *subochraceus*, I do not feel prepared to pronounce them identical. I have two specimens from Massachusetts which were supposed to be *subochraceus*, by Mr. Fish, and from which the drawings of the genitalia on Plate IV. were made. In these specimens the palpi are longer than in *lacteodactylus*, and I do not think they are the same.

PTEROPHORUS HELIANTHI.

Lioptilus helianthi Wlsm., Pter. Cal. and Ore., p. 54, Plate III., fig. 11 (1880).

Expanse of wings, 24 mm. Head and thorax whitish; palpi brownish; antennæ white, dotted with brown above. Abdomen whitish. Legs whitish, dotted with brown on the under side of the segments.

Fore wings cream white, with a few scattered brown scales; a brown spot before the base of the fissure and another between that and the costa, upon which is a brown line; the apex of each lobe sprinkled with brown, and on the apex of the first lobe are two or three small brown spots or dashes. Fringes cream white, tinged with brown on the outer margin. Hind wings very pale cinereous; fringes slightly darker about the ends of the feathers.

Habitat. — Southern Oregon. Food plant, *Helianthus*.

PTEROPHORUS STRAMINEUS.

Lioptilus stramineus Wlsm., Pter. Cal. and Ore., p. 41, Plate III., fig. 3 (1880).

Expanse of wings, 19 mm. Head yellowish brown above and in front, yellowish white between the antennæ; palpi and antennæ pale straw color above, brownish beneath. Thorax, abdomen, legs and spurs pale straw color. Fore wings straw color, with a slightly brownish streak extending from the base along the lower half of the wing, and one running obliquely on the costa, pointing inward toward a brown spot at the base of the fissure. Fringes grayish, slightly tinged with brown. Hind wings and fringes pale grayish brown.

Habitat. — Southern Oregon. Early stages and food plant unknown.

PTEROPHORUS ANGUSTUS.

Lioptilus angustus Wlsm., Pter. Cal. and Ore., p. 43, Plate III., fig. 4 (1880).

Expanse of wings, 18 mm. Head very pale straw color; palpi straw color above, tinged with brownish on the sides; antennæ whitish, with indistinct ochreous spots above. Thorax and abdomen pale straw color. Legs whitish.

Fore wings narrow, very pale straw color tinged with ochreous; a dark fuscous dot at the base of the fissure. Fringes very pale straw color except at the outer end of the fissure above and below where they are grayish. Hind wings pale cinereous; fringes paler.

Habitat. — California. Early stages and food plant unknown.

It differs from *stramineus* in having no costal streak.

PTEROPHORUS SULPHUREODACTYLUS.

Pterophorus sulphureodactylus Pack., Ann. Lyc. Nat. Hist., N. Y., Vol. X., p. 266 (1873).

Lioptilus sulphureus Wlsm., Pter. Cal. and Ore., p. 48, Plate III., fig. 7 (1880).

Expanse of wings, 25 mm. Head ochreous. Palpi whitish yellow, streaked with ochreous; antennæ long, yellowish, tinged with fuscous. Thorax and abdomen sulphur yellow, streaked with ochreous scales. Legs whitish ochreous, streaked with brown.

Fore wings with the first lobe produced into a very acute point, the second lobe broad halberd-shaped, unspotted, clear sulphur yellow, slightly tinged with brownish on the outer fourth of the costa. A minute brown dot before the base of the fissure.

Fringes pale yellowish white, cinereous on the hind margin. Hind wings whitish, thickly dusted with cinereous. Fringes concolorous.

Habitat. — California. Early stages and food plant unknown.

PTEROPHORUS MATHEWIANUS.

Leioptilus Mathewianus Zell., Lep. Westk. Am., p. 23 (1874).

Expanse of wings, 24 mm. Head brownish gray behind; palpi whitish gray; antennæ dust gray, faintly annulated on the basal third with whitish. Thorax and abdomen whitish gray. Legs light gray, all the femora and tibiæ brownish ochre, lightest on hind legs.

Fore wings pale reddish gray, sprinkled with black scales, especially on the margin. A diffuse brown dot on the cell, nearer to the base of the wing than to the fissure. Before this is a more distinct dot, variable in form and size, and sometimes a pale dot at the base of the second lobe. A white longitudinal spot under the first-named dot, and before the same an almost pure white stripe runs to the fold, where it widens and sends out a slender line through the middle of the second lobe to its outer margin. A dark-brown line bordered with white on each side runs to the dot on the fissure, and a brown indistinct dot rests on the middle of the first lobe; two brown spots on the apex of the second lobe and a short brown cross line at the base of the fringes of the outer margin. Hind wings clear brownish gray, with a silky luster.

Habitat. —Vancouver Island. Early stages and food plant unknown.

PTEROPHORUS PALEACEUS.

Leioptilus paleaceus Zell., Beitr., p. 126 (1873).
Lioptilus paleaceus Wlsm., Pter. Cal. and Ore., p. 41, Plate III., fig. 2 (1880).
Leioptilus sericidactylus Murtf., Am. Ent., Vol. III., p. 235 (1880).

Expanse of wings, 21-25 mm. Head yellowish brown, pale between the antennæ; antennæ whitish. Thorax dull yellowish white. Abdomen dull yellowish, with fine longitudinal brownish lines. Legs yellowish white, with fuscous shadings on the under side.

Fore wings very pale brownish gray, with a brownish spot before the fissure. Fringes concolorous with the lobes. Hind wings of the same color as the fore wings. Fringes paler, except at the apices.

Habitat.—Ohio, Illinois, Missouri, Texas, California, Oregon. Food, Iron Weed (*Vernonia noveboracensis*).

An examination of the genitalia of the types of *paleaceus* and also of *sericidactylus* proves them to be identical.

"*Larva.*—Length, 0.55 inch; diameter, 0.10 inch; form, subcylindrical. Color when young, dingy white, with a tinge of green, becoming at maturity pale glaucous, often varying, especially in the late fall brood, to dull salmon. Dorsal hairs proceeding from prominent tubercles, and of two sizes in each tuft, each of the shorter ones tipped with a minute pellucid bead of viscid fluid, to which pollen and bits of leaves often adhere. Lateral ridge well defined. Prolegs long and narrow. When mature, the larva weaves a dense mat of silk, upon which it extends itself, remaining quiescent for two or three days, the dorsal surface acquiring, meanwhile, a translucent lilaceous hue, with three greenish-white longitudinal stripes, of which the medio-dorsal is most distinct and continuous.

"*Pupa*, with ventral surface closely appressed to the mat of silk, to which the anal hooks are firmly attached. An upright or inverted horizontal position seems to be preferred, although there is no thoracic band or other support for the anterior part of the body.

"Average length, 0.45; diameter, same as larva, tapering rather abruptly from seventh abdominal segment backward. Wing sheaths narrow, free at the blunt tips. Dorsum with prominent subdorsal ridges. Color and markings quite variable. In the spring brood commonly dull green, with indistinct lateral yellow stripes. In the fall brood the dorsum is pale yellow or flesh color, with two fine, indistinct, medio-dorsal lines of lilac color; subdorsal ridge pale, inclining to lilac on outer side. In subdorsal space are two nearly continuous, quite heavy, black or fuscous lines, separated by a broad pale stripe, from two narrow, interrupted dark lines, one beneath, the other above, the stigmata. On the thorax the dark stripes are represented by two slightly diverging dashes on each side. Situated in the subdorsal ridge, at the posterior edge of each segment, are a pair of small, geminate, piliferous warts, each bearing a sparse tuft of light sprangling hairs. The last larval skin, rolled into a little hairy ball, is often supported over the back of the chrysalis, raised above it on the hairs of the sub-dorsal ridges. The pupa is quite active and irritable, striking about in all directions when meddled with." (Murtfeldt.)

PTEROPHORUS AGRAPHODACTYLUS.

Pterophorus agraphodactylus Walk., Cat. Lep. Het., Vol. XXX., p. 94 (1864).

Lioptilus agraphodactylus Wlsm., Pter. Cal. and Ore., p. 46, Plate III., fig. 6 (1880).

I have not seen this species, and therefore quote Lord Walsingham's description: —

"Head whitish in front, touched with brownish ochreous towards the thorax and in front; antennæ whitish, browner beneath; palpi very short. Thorax yellowish white.

"Fore wings remarkably narrow, dirty white, with a faint yellowish tinge, streaked longitudinally with faint slender lines of brownish gray, apparently following the neuration; the widest and most conspicuous of these runs parallel to the costa from the base of the wing to the middle of the anterior lobe, where it is diffused in a faint shade towards the costa, sending two slender and scarcely discernible lines to the apex and inner margin. There are two slender brownish-gray lines on the dorsal half of the wing, the upper one, coming from the base, passing below the cleft, where it throws off a branch beneath and running along the upper edge of the second lobe to its apex; the lower coming also from the base, and attaining the dorsal margin below the base of the cleft. The costa pale; the cilia tinged with gray. Hind wings and fringes pale cinereous. Abdomen and legs slightly yellowish white. Underside uniformly pale cinereous, except the costa and the fringes of the anterior lobe within the fissure which are whitish.

"Expanse, 25 mm."

Habitat. — St. Domingo, Southern Oregon. Early stages and food plant unknown.

PTEROPHORUS INCONDITUS.

Lioptilus inconditus Wlsm., Pter. Cal. and Ore., p. 44, Plate III., fig. 5 (1880).

Expanse of wings, 19 mm. Head pale brownish gray, paler between the antennæ; palpi brownish gray; antennæ pubescent, whitish, the basal segment enlarged and with a few erect scales on its inner side; thorax and abdomen slightly tinged with yellowish. Legs yellowish white.

Fore wings very pale brownish gray or bone color, without any markings except faint traces of darker lines upon some of the veins. Fringes slightly paler than the wings. Hind wings and fringes very slightly darker, with a more decided cinereous tinge.

Under side of all the wings brownish gray, with the costal margin of the fore wings slightly paler.

Habitat. — California, Washington, D. C. Early stages and food plant unknown.

PTEROPHORUS PARVUS.

Lioptilus ?parvus Wlsm., Pter. Cal. and Ore., p. 55, Plate III., fig. 12 (1880).

As I have no example of this species, I quote Lord Walsingham's description: —

"Head grayish white, a scarcely paler frontal tuft projecting slightly above the long, well clothed but sharply pointed palpi, which are about twice the length of the head; antennæ pubescent, grayish.

"Fore wings cleft to scarcely one-third of their length, with no posterior angle to the the upper lobe, which is rather narrow, acuminate and appressed at the apex, dusty grayish, sprinkled with fuscous scales, which form an elongate shade, extending from an ill-defined antemedian fuscous dot to the base of the anterior and to the apex of the posterior lobe; a small fuscous dot lies immediately before and slightly below the base of the fissure; there is a slight fuscous shade along the posterior margin of the upper lobe, of which the costal portion is rather pale ochreous; the costa itself whitish. The cilia along the apical margin of both lobes are grayish, spotted along their base with four or five groups of fuscous scales, of which one is at the extreme apex of the upper lobe. The anal angle appears to be slightly more defined in the second lobe of the fore wings, and the fissure rather wider at the base than is usual in this genus. Hind wings cinereous. Abdomen grayish white; the legs whitish, first two pairs touched at the sides with grayish fuscous. The first pair of spurs on the hinder tibiæ are unequal in length; the second pair equal to the longest of the other two.

"Expanse, 15 mm."

Habitat. — California. Early stages and food plant unknown.

PTEROPHORUS KELLICOTTII.

Lioptilus Kellicottii Fish, Can. Ent., Vol. XIII., p. 141 (1881).

Expanse of wings, 28–30 mm. Head ochreous brown, whitish between antennæ. Palpi rather long and slender, second segment with a small tuft of raised scales on the upper side at the extremity. Antennæ pale ochreous, brownish beneath; thorax and abdomen pale brownish ochreous, the latter striped longitudinally with pale brown lines. Fore and middle legs brownish ochreous; hind legs whitish ochreous, tarsi paler.

Fore wings pale ochreous, dusted more or less with brownish scales, which in some examples form longitudinal streaks on the costa and basal half of the median space; a dark-brown dot on the base of fissure; two brown dashes on the costa near the apex, one on the hind margin of first lobe near the apex, usually four at the end of the second lobe on veins 2, 3, 4 and 5. Fringes concolorous. Hind wings, also under side of all the wings, cinereous brown, with a silky lustre. Fringes darker.

Habitat. — New York. Food, *Solidago.*

"The larva, when first examined, August 22, was .3 of an inch long; color light yellow, head and shield darker, the oblique anal plate almost black, bearing hairs and hooks; dorsal and subdorsal lines pinkish. By the middle of September it abandons the branches, being then .45 of an inch in length, and bores into the stalk a few inches above the ground; it makes its way down the pith into the roots, well under the ground, where it passes the winter. I fetched several examples from the fields in January for examination; they were then .58 to .6 of an inch in length, lighter in color, with the longitudinal lines of pink brighter than in autumn, the eighth segment conspicuously marked on the back by pink. There are few hairs over their smooth bodies; on the last ring, however, there is a brown or black chitinous disc, with a circle of long brown hairs about its circumference; in the centre of this disc there is a small papilla, with two stout, straight black teeth, pointing rearwards; these teeth are hooked upward in the autumn stage. The hairs render the plate sensitive to touch, and help to brush fragments from their long, narrow galleries, while the teeth assist in backward motion in them. The mature larvæ obtained in May differ but slightly from these, except that they are then .7 of an inch long, and the pink stripes and marks are brownish. The fourth, fifth and sixth segments are smaller than those preceding or following them. They are quite active, moving up and down their burrows rapidly.

"By the middle of May the caterpillar has worked its way back to the place of entrance in autumn, enlarging its way to accommodate its increased size, and, after loosely stopping the upper part with a few chips, retires and changes to the pupa. It is then .6 of an inch in length, slender, cylindrical. Color white, except the oblique disc or plate terminating the head, which is made dark by many teeth-like elevations on its surface. The abdominal segments are clothed with hairs, and the last four segments have each a transverse row of teeth on the dorsal part, reminding one of a Tortrix or Cossus pupa. The conical tip of the abdomen has many teeth; these teeth, together with the roughness on the head, enable the pupa to worm its way up and down the burrow with readiness. When removed from the stem to the table, it travels about, rolling and worming its way very much as do the pupæ of certain stem-boring beetles. The wing and limb covers are free for a considerable distance from their tips." (Kellicott.)

PTEROPHORUS GRANDIS.

Lioptilus grandis Fish, Can. Ent., Vol. XIII., p. 141 (1881).

Expanse of wings, 34 mm. Head, palpi, antennæ, thorax and abdomen of nearly a uniform pale brownish-ochreous color. Legs brownish ochreous, with tarsi somewhat lighter.

Fore wings pale brownish ochreous, in some species with a few scattered faint brownish dots on the second lobe. Fringes slightly darker. Hind wings very slightly browner than fore wings, with the fringes still darker.

Habitat. — California. Early stages and food plant unknown.

PTEROPHORUS MONODACTYLUS.

Alucita monodactyla Linn., Syst. Nat., Ed. X, Vol. I., p. 542 (1758).
Pterophorus cineridactylus Fitch, N. Y. Rep., Vol. I., p. 848 (1854).
Pterophorus nævosidactylus Fitch, N. Y. Rep., Vol. I., p. 849 (1854).
Pterophorus pergracilidactylus Pack., Ann. Lyc. N. Y., Vol. X., p. 265 (1873).
Pterophorus monodactylus Wlsm., Pter. Cal. and Ore., p. 39, Plate II., fig. 16; Plate III., fig. 1 (1880).

Expanse of wings, 22–26 mm. Head and thorax pale gray, sprinkled with brown scales. Palpi short, tipped with brown; antennæ grayish white, spotted with fuscous above. Abdomen grayish ochreous, striped with fuscous and brown scales on the sides; a dorsal row of brown dots, one at the base of each segment. Legs grayish, with the joints enlarged and covered with brownish hairs; a tuft of scales near the middle of the hind tarsi on the side opposite the spurs.

Fore wings varying from pale grayish to pale reddish brown, often mixed with white and sometimes with a few black scales; stripes or streaks of dark brown or blackish scales on the costa and hind margin; before the fissure a brown spot, sometimes tapering to a point toward the base; an elongated spot of brown scales on the costa, half-way between the latter and the apex, with two smaller ones between it and the apex; one or more small blackish dots on one or both lobes near the apex. Fringes grayish, tinged with fuscous on the outer third of fissure. Hind wings gray or fuscous, with a silky lustre; fringes slightly darker.

This species is exceedingly variable both in color and markings, some examples being very light with but few spots, while others are reddish brown.

Habitat. — Europe; Maine to California. Food, *Convolvulus sepium*, *Convolvulus arvensis*, *Chenopodium album*, *Atriplex patula*.

"*Larva.* — Length, when at rest, about five-eighths of an inch, and stout in proportion. Head polished and rather small, narrower than the second segment. Body uniform and cylindrical, tapering a little posteriorly. Segmental divisions well defined and deeply cut ventrally; each tubercle emits a tuft of short but rather strong hairs. Ground color bright yellowish green, more decidedly green on the back; head pale yellow, the mandibles light brown. A fine but clear yellowish white line forms the dorsal stripe; there is a much broader stripe of the same color along the spiracular region, and the space between it and the spiracles is prickled with streaks and spots of the same color. Spiracles black, hairs grayish. Ventral surface, legs and prolegs uniformly pale green. The pupa, although attached by the tail, was laid flat along the top of the cage." (Porritt.)

PTEROPHORUS CRETIDACTYLUS.

Pterophorus cretidactylus Fitch, N. Y. Rep., Vol. I., p. 849 (1854).
Œdematophorus occidentalis Wlsm., Pter. Cal. and Ore., p 37, Plate II., figs. 13, 14 (1880).
Pterophorus cretidactylus Fern., Can. Ent., Vol. XXV., p. 96 (1893).

Expanse of wings, 26 mm. Head whitish ochreous, slightly tinged with fawn color on the front; palpi fawn color; antennæ whitish, faintly spotted with fawn color; thorax whitish ochreous. Abdomen fawn color. Fore and middle legs white, with dark, brush-like tufts on the joints; hind legs tinged with fawn color, whitish on the inner sides; segments slightly thickened, not annulated.

Fore wings whitish ochreous, the costa, apex and hind margin tinged with fawn color; a dark fawn-colored spot before the base of the fissure, more or less connected obliquely with an elongated spot of the same color on the costa; a light space on each side of the costal spot. Fringes whitish ochreous, tinged with pale fawn color. Hind wings and fringes lustrous, pale fawn color.

Habitat. — New York, California. Early stages and food plant unknown.

PTEROPHORUS EUPATORII.

Œdematophorus cretidactylus Zell., Lep. Westk. Am., p. 22 (1874).
Œdematophorus cretidactylus Wlsm., Pter. Cal. and Ore., p. 35 (1880).
Œdematophorus cretidactylus Kell., Bull. Buf. Soc., Vol. IV., p. 2 (1882).
Alucita eupatorii Fern., Can. Ent., Vol. XXV., p. 96 (1893).

Expanse of wings, 22–24 mm. Head dull reddish brown; thorax pale brown; legs brown, darker at the middle and ends of the tibiæ; segments of the tarsi white at the base and brown at the tips; spurs white in the middle and brown at the tips.

Fore wings pale ochre yellow, whitest on the costal portion, and sprinkled with dark-brown scales to such an extent as to give them a wood-brown color. These dark-brown scales form an antefissural spot, which in some specimens is concave on the outside and extended obliquely up and out, nearly reaching a dark-brown costal streak over the end of the fissure, beyond which are two costal dark-brown spots, the first of which is the smaller. The brown on the second lobe sometimes gives this part of the wing a streaked appearance. Fringes smoke brown, cut with whitish once on the first lobe and twice on the outer margin of the hind lobe. Hind wings and fringes brownish cinereous.

Habitat. — New York, California, Vancouver Island. Food, *Eupatorium purpureum*.

"*Larva.* — Length, 0.55 of an inch; color of skin greenish, striped with wine color and white; hairs dusky, lighter laterally. Dorsal line white, interrupted with circles and bordered laterally with wine color. That part of the dorsal space in which the tubercles stand, much lighter in hue; subdorsal and stigmatal lines white, bounded by the same shade as the dorsal. Head light green, spiracles ringed with brown.

"*Pupa.* — Color, green, ornamented with wine-colored and white lines. It has the same size and habits as *homodactylus;* the tubercles are similar. It is a little thicker, the anterior end more obtusely truncated and less bilobed. The hairy clothing similar to *homodactylus*, but the hairs not so smooth as in that pupa." (Kellicott.)

PTEROPHORUS GUTTATUS.

Œdematophorus guttatus Wlsm., Pter. Cal. and Ore., p. 36, Plate II., fig. 12 (1880).

Expanse of wings, 25 mm. Head and palpi whitish, sprinkled with cinereous, the palpi fuscous at the sides; thorax and abdomen whitish cinereous. Hind legs white, with two slightly fuscous annulations.

Fore wings whitish cinereous, paler at the base, dusted with fuscous scales toward the costa and hind margin; a white spot, generally bordered on the inner edge by two fuscous scales, lies at the base of the fissure; another similar spot is sometimes indicated before the middle of the hind margin. Fringes of the outer margin and fissure cinereous fuscous, slightly interrupted with whitish. Hind wings pale cinereous. Fringes paler.

Habitat. — California. Early stages and food plant unknown.

PTEROPHORUS CINERACEUS.

Œdematophorus cineraceus Fish, Can. Ent., Vol. XIII., p 73 (1881).

Expanse of wings, 28 mm. Front of head dark grayish brown, vertex pale cinereous. Palpi grayish brown, ascending, third segment short. Antennæ cinereous, dotted above with dark brown. Abdomen cinereous, marked with reddish-brown scales. Legs brownish cinereous, sprinkled with dark-brown scales; a band on the middle and on the end of the middle tibiæ dark grayish brown, spurs tipped with dark brown; tarsi whitish cinereous, slightly brownish at extreme end of segments.

Fore wings cinereous, tinged with brownish, and very thinly sprinkled with dark-brown scales. These scales form a median spot before the base of the fissure, bordered on the outside with white. A longitudinal brown spot occurs on the costa opposite the base of the fissure, and two smaller ones toward the apex. Fringes brownish cinereous. Hind wings and fringes brownish cinereous.

Habitat. — Washington. Early stages and food plant unknown.

PTEROPHORUS BARONI.

Œdematophorus Baroni Fish, Can. Ent., Vol. XIII., p. 73 (1881).

Expanse of wings, 30 mm. Front of head brownish cinereous, vertex lighter. Palpi rather stout, third segment very short and blunt. Antennæ pale cinereous, dotted above with dark brown.

Thorax and abdomen pale brownish cinereous, the latter marked dorsally by a row of fine black dots on each segment beyond the third. Anterior and middle femora brownish cinereous, tibiæ grayish, tarsi whitish cinereous. Hind femora and tibiæ pale brownish cinereous, spurs short, tipped with black.

Fore wings brownish cinereous, ochreous on the inner margin and second lobe, the whole surface sprinkled with fine black scales. Fringes concolorous with the wings. Hind wings and fringes dark cinereous.

Habitat. — California. Early stages and food plant unknown.

PTEROPHORUS GRATIOSUS.

Œdematophorus gratiosus Fish, Can. Ent., Vol. XIII., p. 73 (1881).

Expanse of wings, 22 mm. Head and palpi dark brown; antennæ pale brownish, dotted above with white and dark-brown scales. Thorax grayish brown, anterior portion lighter. Abdomen fawn brown. Legs grayish brown, tarsi pale cinereous, slightly darker on the extremities of segments.

Fore wings pale cinereous, dusted with dark brown; an oblique brown spot occurs before the base of the fissure and a longitudinal brown costal line nearly opposite the base of fissure. Fringes concolorous with wings. Hind wings and fringes brownish cinereous, third feather whitish.

Habitat. — California. Early stages and food plant unknown.

PTEROPHORUS LUGUBRIS.

Œdematophorus lugubris Fish, Can. Ent., Vol. XIII., p. 140 (1881).

Expanse of wings, 27–29 mm. Head and palpi dark smoky brown. Antennæ dotted above with white and blackish scales. Thorax light smoky brown. Abdomen slender, dark smoky brown, thickly sprinkled with very dark scales. Legs grayish brown, the middle tibiæ whitish just before the middle and end; all the tarsi whitish at base of joints; spurs whitish at base.

Fore wings dark smoky gray, dusted with dark brown scales; a longitudinal black dash on the costa, opposite the base of fissure; an obscure blackish spot before the base of fissure, bordered outwardly by gray scales. Faint indications of two smaller blackish spots on the costal margin of anterior lobe. Fringes smoky gray, with a few whitish hairs on the hind margin of anterior lobe near the apex. Hind wings and fringes, as well as under side of wings, cinereous.

Habitat. — California. Early stages and food plant unknown.

PTEROPHORUS GRISESCENS.

Œdematophorus grisescens Wlsm., Pter. Cal. and Ore., p. 34, Plate II., fig. 11 (1880).

Expanse of wings, 29 mm. Head and palpi gray, with a fuscous tinge on the apex of the palpi. Antennæ spotted with gray and fuscous. Thorax and abdomen grayish, sprinkled with fuscous. Legs grayish white, tinged on the segments and on the tips of the spurs with fuscous.

Fore wings gray, slightly spotted with white and dusted with fuscous scales, the hind portion touched with ferruginous. A white space on the costa before the base of the fissure, and another beyond and obliquely connected by whitish scales with the base of fissure; a whitish spot before the middle of the hind margin and an indistinct fuscous spot above it. Fringes mottled with white and grayish fuscous. Hind wings cinereous; fringes whitish mixed with gray.

Habitat. — Southern Oregon. Food, *Artemisia.*

PTEROPHORUS INQUINATUS.

Œdematophorus inquinatus Zell., Beitr., p. 125 (1873).
Œdematophorus ambrosiæ Murtf., Am. Ent., Vol. III., p. 236 (1880).

Expanse of wings, 19 mm. Head and thorax gray, spotted with white; palpi small, porrect, acute, whitish, touched with brown outwardly. Antennæ whitish, spotted with brownish, white at the base on the under side. Abdomen gray.

Fore wings dust gray, thickly dusted with white and brown scales, forming scattered flecks or blotches, one of which is generally present on the middle of the space between the base of the wing and the fissure; a larger one before the fissure and separated from it by a whitish space, against which its oblique outer margin is excavated; below this is a longitudinal streak of scales, bordered basally by a white spot and separated from the spot before the fissure by a whitish space. Two blackish streaks or spots occur on the costa, the larger one above the base of fissure, the other half-way between it and the apex of the wing. Fringes grayish, cut with white under the apices of the lobes and on the anal angles, where there is a white wisp. A similar wisp before the apex and on the anal angle of the second lobe. A brown dot sometimes rests on the base of each of the three wisps. Hind wings brownish gray, a diffuse brown dot on the apex of each feather or at least on the first. Fringes brighter.

Habitat. — Alabama, Texas, Missouri, Colorado, Arizona. Food, Rag-weed (*Ambrosia artemisiæfolia*).

" *Larva.* — Length, 0.35; diameter, 0.09. Form depressed. Color, pale greenish gray, with very characteristic dark markings and lateral tufts of long, white silken hairs. Head small, light brown, corneous, retractile. Segment 1 with a dilated, partially free shield-like collar, covering top and projecting over the head. The ornamentation of this collar consists of five central minute brown dots, with four still smaller black ones on each side, from each of which proceeds a short curving bristle. The projecting edges fringed with soft light hairs. Segments 2 and 3 gradually broadening backward, ornamented on dorsum with two oblong, pale, brown spots on either side of a triangle of very minute black dots, and having a larger black dot on each outer side. Two short bristles arise from each of the more conspicuous spots. Abdominal segments each with four somewhat elevated brown spots, from which proceed single, short, backward-curving bristles. Between the posterior pair of brown spots are two smaller black ones, each of which forms the base of a very short clubbed piliferous process, which turns backward, resting flat upon the surface.

" The stigmata are annulated with black, and obliquely above and forward of each are two small brown dots. The lateral tufts are below the stigmata, and each is composed of from seven to nine long hairs, which under the lens are remotely pectinate. A little above and back of each of these tufts is a semicircle of fine, scale-like bristles. The prolegs are very short.

" *Pupa.* — Length, 0.25. Swollen and blunt anteriorly. Color, pale fulvous, with a roseate hue on dorsum. Dorsal surface beset with tufts of dingy hairs, with a lateral fringe of single straight hairs, which serve to secure it more firmly to the mat of silk upon which it rests. Dorsum marked near the head with two large, dull-brown spots, and an indistinct longitudinal stripe of the same color on the abdomen. On either side of the thorax is a small, velvety dark-brown dot." (Murtfeldt.)

Genus STENOPTILIA Hüb., Verz., p. 430 (1826).

Vertex smooth; front cone shaped, smoothly scaled; palpi extending beyond the frontal projection, the second segment somewhat triangular, with projecting scales above at the end, the third segment very small and cylindrical. Fore wings fissured about one-third of their length, the lobes narrow and with very oblique outer margins, but with more or less distinctly visible anal angles. The feathers of the hind wings are dissimilar in form: the first is the widest; the second is smaller, and has a long, produced apex; the third is linear, without dark scales in the hind fringe. The venation is complete, as shown on Plate III., figs. 1 and 2.

SYNOPSIS OF THE SPECIES.

1.	Expanse of wings less than 15 mm., ...	*pumilio.*
	Expanse of wings more than 15 mm., ...	2.
2.	With a dark-brown streak on the middle of first lobe, . .	3.
	Without a dark streak on the middle of first lobe, .	*pterodactyla.*
3.	Second lobe without any trace of a brown streak, .	*exclamationis.*
	Second lobe with a more or less complete brown streak,	*semicostata.*

STENOPTILIA PUMILIO.

Mimeseoptilus pumilio Zell., Beitr., p. 124 (1873).

Expanse of wings, 12 mm. Head reddish gray, front whitish; palpi very thin, filiform, horizontal, whitish. Antennæ pale gray, white towards the base on the outside. Thorax reddish gray. Abdomen yellowish white at the base and end. Legs slender, white, the first pair of spurs on hind tibiæ unusually long.

Fore wings unusually short and broad, very bright fawn color, darkest on the costal margin of the anterior lobe; costal vein white for two thirds of its length; a long blackish streak on the fold at the basal fourth of the wing; a long, conspicuous point in the middle between this and the fissure, and before these one or two long, confused flecks. Fringe of anterior lobe white or gray, with scattered black scales, with two black, somewhat commingled dots on the outer margin near the anal angle. Fringe of the second lobe gray, thickly sprinkled with deep black scales, which are united with three black spots on the hind margin; at the apex it is whitish, and marked with a row of unequal, somewhat commingled dots, which do not reach to the base of the fringe. Hind wings brownish gray, with much lighter fringes. On the apex of the first and second feathers a small black dot may be seen in certain lights, most distinct on the under side, where the apex of the third feather is dark brown.

Habitat. — Texas. Early stages and food plant unknown.

STENOPTILIA PTERODACTYLA.

Alucita pterodactyla Linn., Faun Suec., p. 371 (1761).

Expanse of wings, 21–24 mm. Head ashy brown; palpi long, acuminate, whitish at the tips; antennæ brownish above, whitish beneath. Thorax ashy brown, with a few darker scales. Abdomen fuscous, striped with pale ochreous lines and with a few dark-brown dots at the ends of the segments. Legs ochreous brown on the outside, whitish on the inner sides, tarsi very pale ochreous.

Fore wings reddish brown, the entire costa and the apex of the second lobe heavily sprinkled with dark-brown scales; a dark-brown reniform spot at the base of the fissure. Fringes ashy brown, with a very pale line at their bases. Hind wings fuscous with ashy brown fringes.

Habitat. — New York. Food, Speedwell (*Veronica chamædrys*).

"*Larva.* — Length, about five-eighths of an inch, and scarcely so stout as seems usual in the genus. Head small, and narrower than the second segment; it is polished, rather flat in front, but rounded at the sides. Body cylindrical, of fairly uniform width, but tapering a little at the extremities; segmental divisions well defined; the skin, with a soft and half-transparent appearance, is sparingly clothed with short hairs. There are two varieties, which are perhaps about equally numerous. In one of them the ground color is a bright grass green; in the other it is equally yellow green; in both forms the head is pale yellowish brown, very prettily reticulated with intense black. The dark-green, or, in some of the specimens, dark-brown alimentary canal forms the dorsal stripe; subdorsal lines rather indistinct, grayish white; below there is a still more indistinct waved line of the same color; there is, again, a similarly colored faint line along the spiracular region, and the segmental divisions are also of this pale color. In some specimens the hairs are gray; in others, brown. Ventral surface uniformly of the same color as the ground of the dorsal area; the legs reticulated and the prolegs tipped with black.

"*Pupa.* — The pupa is attached by the tail only, is rather long, but slender. The head, which is the thickest part, is abruptly rounded, and has the snout very prominent; thorax and abdomen rounded above, rather flattened beneath, and attenuated strongly to the anal point; eye, leg and wing cases fairly prominent, the last prolonged a considerable distance over the abdominal segments." (Porritt.)

STENOPTILIA EXCLAMATIONIS.

Mimeseoptilus exclamationis Wlsm., Pter. Cal. and Ore., p. 32, Plate III., fig. 10 (1880).

Expanse of wings, 22 mm. Head and palpi above, gray, with brown scales on the sides and beneath the palpi; thorax gray, with a brown spot on the top. Antennæ brownish gray. Abdomen ochreous brown. Legs brownish above, whitish beneath; feet white.

Fore wings gray, sprinkled with fuscous; costa fuscous; a row of fuscous spots runs from the base along under the cell for one-third the length of the wing; a small fuscous dash under the costa before the middle. Two fuscous spots before the end of the fissure, and beyond them, on the first lobe, a fuscous dash, pointing toward the upper spot, both together forming an exclamation point; above, the costa is spotted with fuscous. Fringes around the fissure white; along the outer margin cinereous, with a fuscous line at their base, but interrupted with white on the middle of the anterior and at the upper angle of the posterior lobe. Hind wings fuscous, with brownish scales. Fringes brownish.

Habitat. — California, Oregon. Early stages and food plant unknown.

STENOPTILIA SEMICOSTATA.

Mimeseoptilus semicostatus Zell., Beitr., p. 123 (1873).

Expanse of wings, 18 mm. Head grayish, with a fine white line above the eyes. Antennæ grayish, white toward the base. Thorax dusted with brown in front, whitish behind. Abdomen slender, pale yellowish, with two black dots on the end of each of the three segments before the last. Legs whitish.

Fore wings brownish gray, shading into pale reddish ochre along the hind margin and upon both lobes. In the middle of the space, between the base and the fissure, is a black dot. At the fissure, at the beginning of the second lobe, is a similar dot, and above it, in one example, is a larger but very distinct wisp-like mark. One example has in the middle of each lobe a fine, brown longitudinal streak; upon the first lobe it is short and in the middle, upon the second it is long and reaches quite to the hind margin. Fringes of hind margin of first lobe whitish at the base, gray outwardly; fringe of outer margin pure white with two black dots, one behind the other. Fringes of second lobe gray, dark outwardly except at the apex, where they are white with two black dots. Hind wings brownish gray; fringes dark gray, with a clear fine line at their base and around the apex of the first two feathers.

Habitat. — Texas. Early stages and food plant unknown.

ORNEODIDÆ.

This family is not so closely related to the Pterophoridæ as was supposed by the early entomologists, and is introduced here merely because there is only a single species known in this country; and, as it is placed near the Pterophoridæ in collections, generally, it may be convenient to treat of it here.

Mr. Meyrick has given the following characters: —

Ocelli distinct. Tongue developed. Maxillary palpi obsolete. Fore wings six-cleft, cell very short, vein 5 absent, 7 separate, 8 and 9 coincident. Hind wings six-cleft, cell very short, 5 absent, 7 out of 6 near origin, 8 free.

GENUS ORNEODES Latr., Prec. d. Car., p. 148 (1796).

Labial palpi long, obliquely ascending, second segment tufted, third segment long and slim. Veins 5, 6, 9 and 10 wanting in the fore wings.

The following well-known European species occurs in the western part of this country: —

ORNEODES HEXADACTYLA.

Alucita hexadactyla Linn., Syst. Nat., Ed. XII., Vol. II., p. 542 (1758).

Alucita montana Ckll., MS., Ent. Mon. Mag., Vol. XXV., p. 213 (1889).

Expanse of wings, 13–16 mm. Head and thorax dark gray on the outside, whitish beneath and within.

Fore wings ochreous gray, with two dark-gray bands edged with whitish crossing them; the first on the middle of the wing and wider on the costa, where it is interrupted in the middle by a white-edged gray spot; the second is subterminal, and wider on the middle of the wing. A dark spot on the costa between the bands, and two others before the first band. A dark-brown or black dot on the apex of each of the feathers of both wings; feathers of the hind wings whitish and dotted with dark gray.

Habitat. — Europe; Missouri, California, Oregon, Canada, Manitoba. Food, *Lonicera*.

The eggs are laid in the early spring, on the flower-buds of the honey-suckle, and the larvæ, when hatched, feed inside of the buds and flowers.

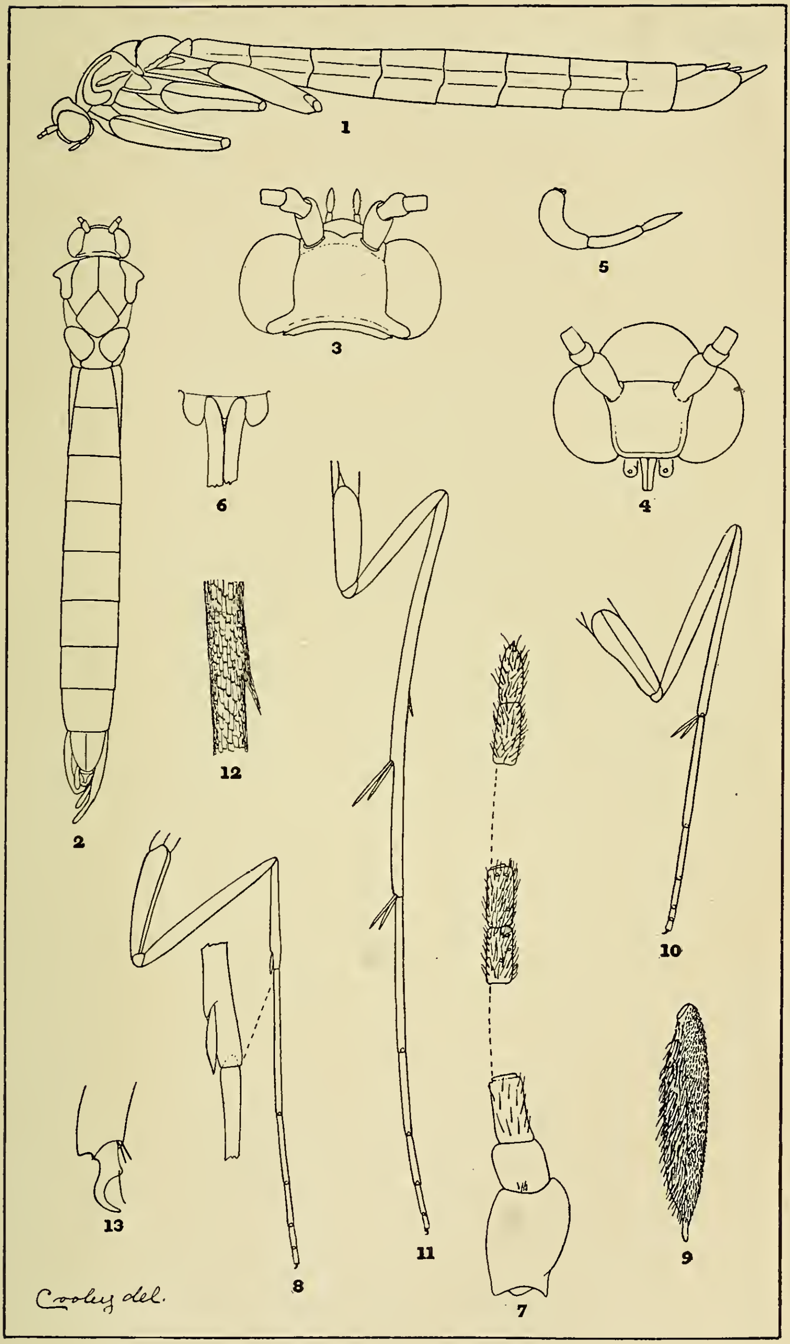
Explanation of Plate I.

External Anatomy of Pterophorus monodactylus.

[All the drawings enlarged.]

Fig. 1. Side view of denuded body of male.
Fig. 2. Top view of denuded body of male.
Fig. 3. Top view of head.
Fig. 4. Front view of head.
Fig. 5. Labial palpus.
Fig. 6. Base of tongue and labrum.
Fig. 7. Antenna of male.
Fig. 8. Fore leg.
Fig. 9. Tibial epiphysis.
Fig. 10. Middle leg.
Fig. 11. Hind leg.
Fig. 12. Portion of hind tibia, showing tuft of scales.
Fig. 13. Claw from the hind leg.

Plate I.



Explanation of Plate II.

Fig. 1. Fore wing of **Platyptilia carduidactyla,** showing veins numbered. *A*, apex of first lobe; *B*, anal angle of first lobe; *C*, apex of second lobe; *D*, anal angle of second lobe.

Fig. 2. Hind wing of **Platyptilia carduidactyla,** showing veins numbered.

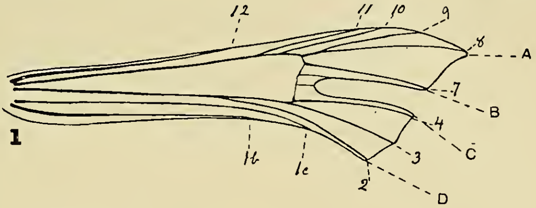
Fig. 3. Fore wing of **Oxyptilus periscelidactylus.**

Fig. 4. Hind wing of **Oxyptilus periscelidactylus.**

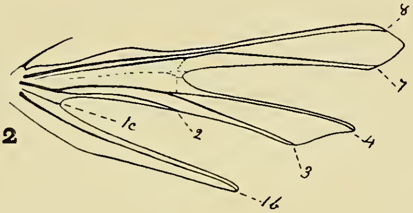
Fig. 5. Fore wing of **Alucita cinerascens.**

Fig. 6. Hind wing of **Alucita cinerascens.**

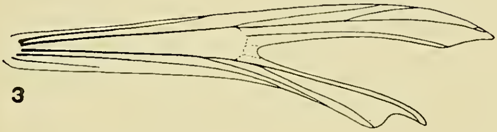
Plate II.



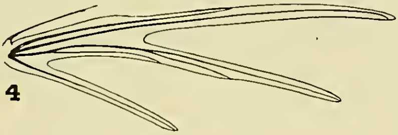
1



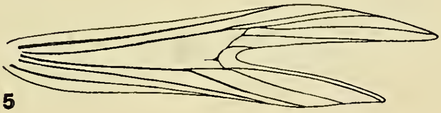
2



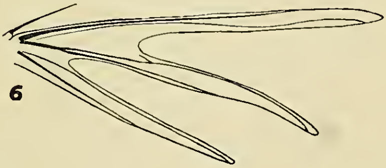
3



4



5



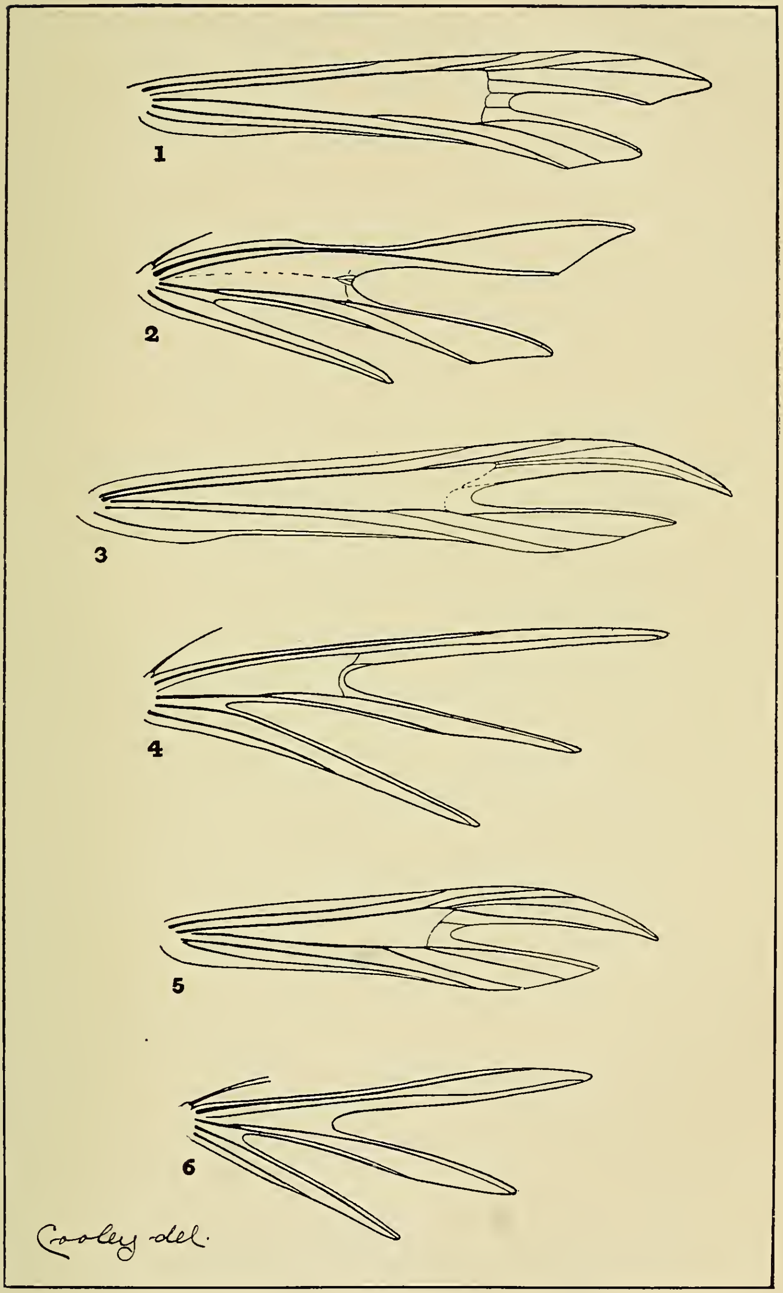
6

Cooley del

Explanation of Plate III.

Fig. 1. Fore wing of Stenoptilia exclamationis.
Fig. 2. Hind wing of Stenoptilia exclamationis.
Fig. 3. Fore wing of Pterophorus monodactylus.
Fig. 4. Hind wing of Pterophorus monodactylus.
Fig. 5. Fore wing of Pterophorus inquinatus.
Fig. 6. Hind wing of Pterophorus inquinatus.

Plate III.



Cooley del.

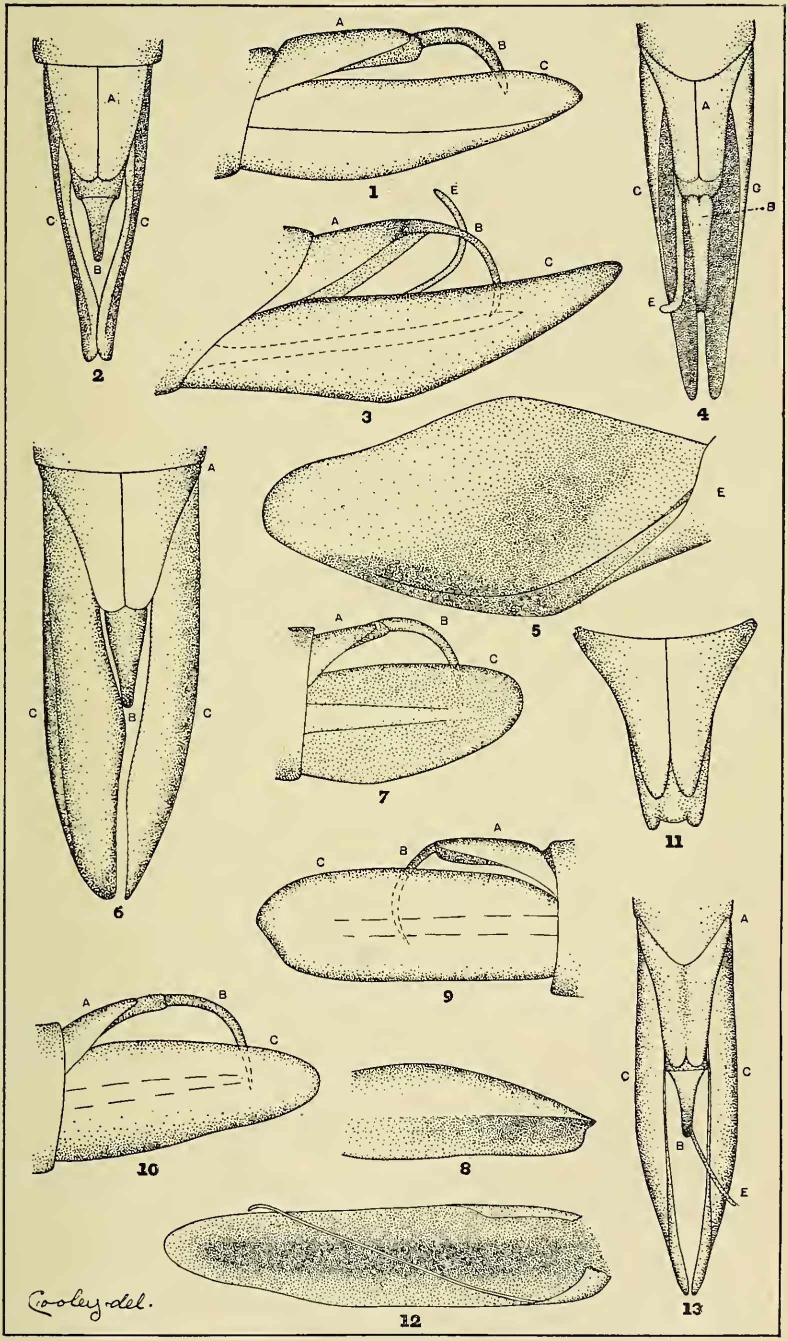
Explanation of Plate IV.

MALE GENITALIA OF PTEROPHORIDÆ.

[Parts of the genitalia: *A*, dorsal plate; *B*, uncus; *C*, clasp; *D*, ventral plate; *E*, elongated internal chitinous appendage.]

Fig. 1. **Pterophorus homodactylus**, side view.
Fig. 2. **Pterophorus homodactylus**, top view.
Fig. 3. **Pterophorus inquinatus**, side view.
Fig. 4. **Pterophorus inquinatus**, top view.
Fig. 5. **Pterophorus kellicottii**, view of inside of left clasper.
Fig. 6. **Pterophorus kellicottii**, top view.
Fig. 7. **Pterophorus stramineus**, side view.
Fig. 8. **Pterophorus stramineus**, outside of left clasper.
Fig. 9. **Pterophorus subochraceus**, side view.
Fig. 10. **Pterophorus sulphureodactylus**, side view.
Fig. 11. **Pterophorus sulphureodactylus**, dorsal plate.
Fig. 12. **Pterophorus lugubris**, view of inside of left clasper.
Fig. 13. **Pterophorus lugubris**, top view.

Plate IV.



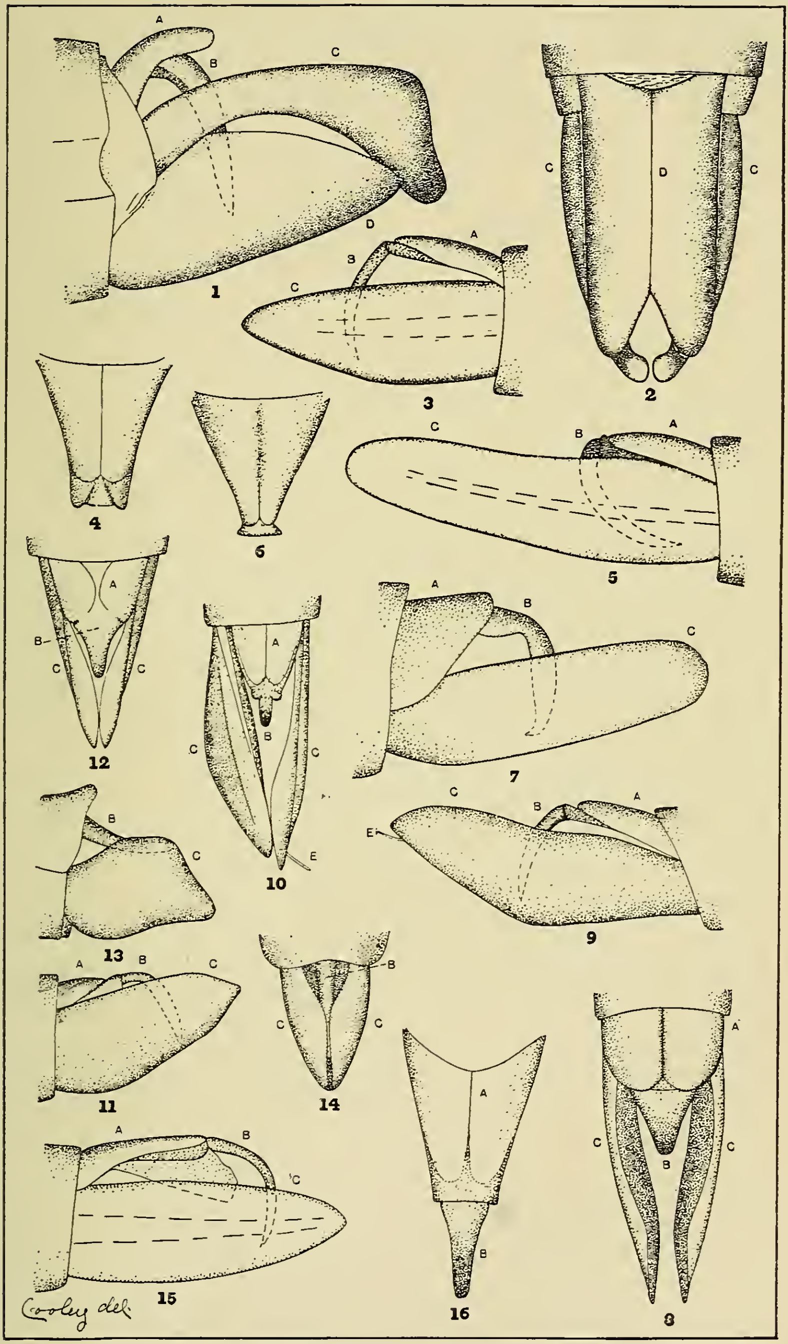
Cooley del.

Explanation of Plate V.

MALE GENITALIA OF PTEROPHORIDÆ

Fig. 1. **Oxyptilus periscelidactylus**, side view.
Fig. 2. **Oxyptilus periscelidactylus**, view from beneath.
Fig. 3. **Pterophorus sulphureodactylus**, side view.
Fig. 4. **Pterophorus sulphureodactylus**, top view of dorsal plate.
Fig. 5. **Pterophorus cineraceus**, side view.
Fig. 6. **Pterophorus cineraceus**, top view of dorsal plate.
Fig. 7. **Platyptilia adusta**, side view.
Fig. 8. **Platyptilia adusta**, top view.
Fig. 9. **Pterophorus grandis**, side view.
Fig. 10. **Pterophorus grandis**, top view.
Fig. 11. **Alucita montana**, side view.
Fig. 12. **Alucita montana**, top view.
Fig. 13. **Trichoptilus ochrodactylus**, side view.
Fig. 14. **Trichoptilus ochrodactylus**, top view.
Fig. 15. **Pterophorus eupatorii**, side view.
Fig. 16. **Pterophorus eupatorii**, top view of dorsal plate and uncus.

Plate V.

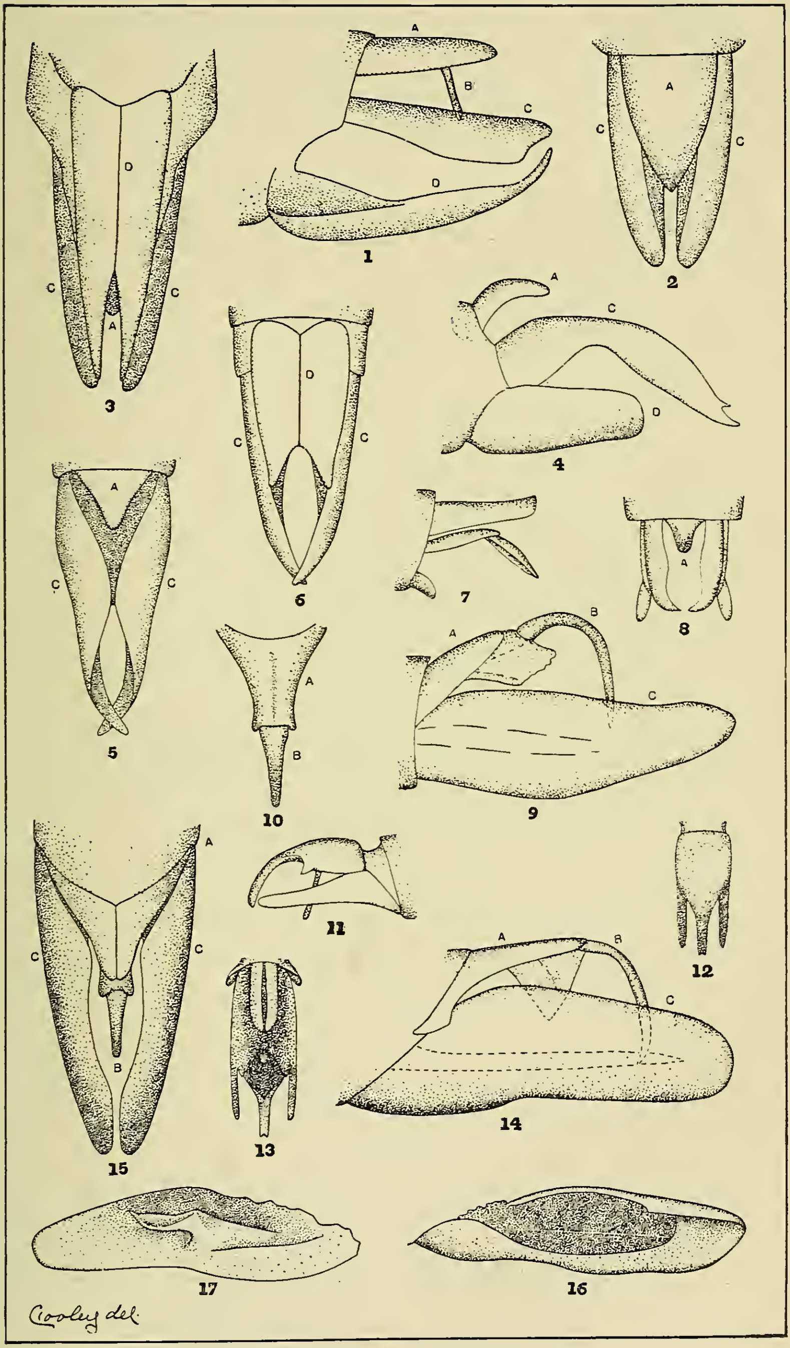

A
B
C
D
1
C
D
C
2
A
B
C
3
4
6
C
B
A
5
A
B-
C
C
12
A
B
C
C
E
10
A
B
C
7
C
B
A
E
9
B
C
13
A
B
C
11
B
C
C
14
A
C
B
C
8
A
A
B
16
B
C
15
Cooley del.

Explanation of Plate VI.

MALE GENITALIA OF PTEROPHORIDÆ.

Fig. 1. **Oxyptilus ningoris**, side view.
Fig. 2. **Oxyptilus ningoris**, top view.
Fig. 3. **Oxyptilus ningoris**, view from beneath.
Fig. 4. **Oxyptilus tenuidactylus**, side view.
Fig. 5. **Oxyptilus tenuidactylus**, top view.
Fig. 6. **Oxyptilus tenuidactylus**, view from beneath.
Fig. 7. **Oxyptilus delawaricus**, side view.
Fig. 8. **Oxyptilus delawaricus**, top view.
Fig. 9. **Pterophorus cretidactylus**, side view.
Fig. 10. **Pterophorus cretidactylus**, top view of dorsal plate and uncus.
Fig. 11. **Orneodes hexadactyla**, side view.
Fig. 12. **Orneodes hexadactyla**, top view.
Fig. 13. **Orneodes hexadactyla**, view from beneath.
Fig. 14. **Pterophorus ambrosiæ**, side view.
Fig. 15. **Pterophorus ambrosiæ**, top view.
Fig. 16. **Pterophorus ambrosiæ**, view of inside of right clasper.
Fig. 17. **Pterophorus ambrosiæ**, view of inside of left clasper.

Plate VI.



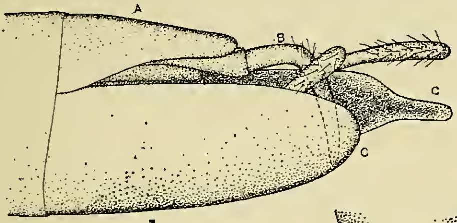
Cooley del.

Explanation of Plate VII.

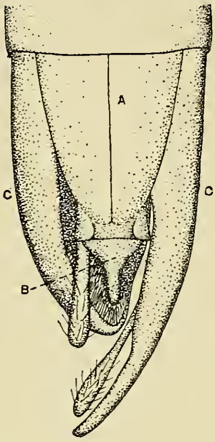
GENITALIA OF PTEROPHORIDÆ.

Fig. 1. **Pterophorus monodactylus**, side view.
Fig. 2. **Pterophorus monodactylus**, top view.
Fig. 3. **Pterophorus monodactylus**, inside view of right clasper.
Fig. 4. **Pterophorus monodactylus**, inside view of left clasper.
Fig. 5. **Pterophorus monodactylus**, female.
Fig. 6. **Platyptilia edwardsii**, side view.
Fig. 7. **Platyptilia edwardsii**, top view.
Fig. 8. **Platyptilia carduidactyla**, side view.
Fig. 9. **Platyptilia carduidactyla**, top view.
Fig. 10. **Platyptilia carduidactyla**, view of inside of left clasper.
Fig. 11. **Platyptilia carduidactyla**, ventral plate.
Fig. 12. **Trichoptilus lobidactylus**, side view.
Fig. 13. **Trichoptilus lobidactylus**, top view.
Fig. 14. **Trichoptilus lobidactylus**, outside view of left clasper.

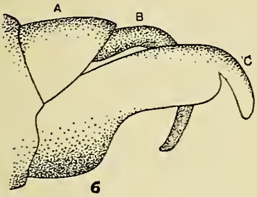
Plate VII.



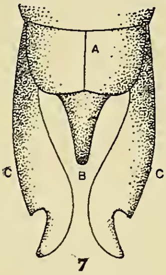
1



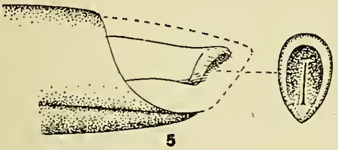
2



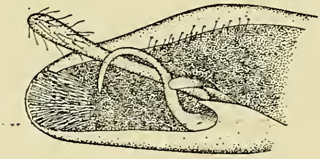
6



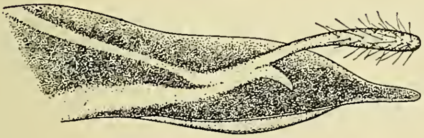
7



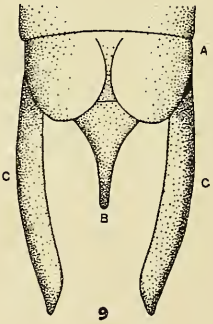
5



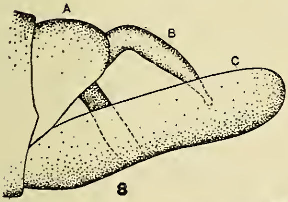
4



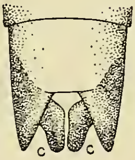
3



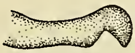
9



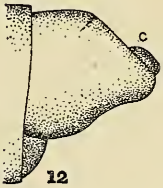
8



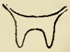
13



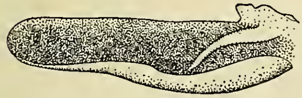
14



12



11



10

Cooley del.

Explanation of Plate VIII.

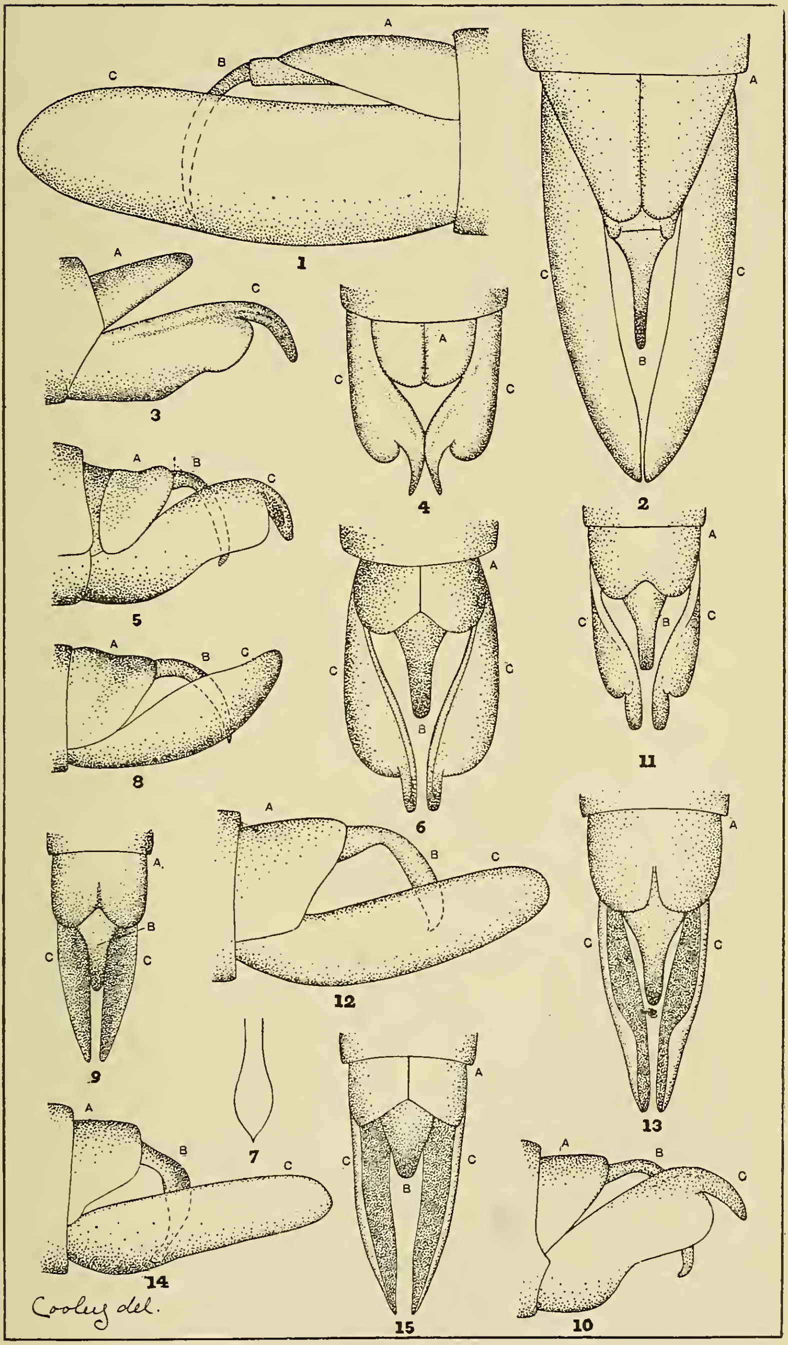
MALE GENITALIA OF PTEROPHORIDÆ.

Fig. 1. **Pterophorus elliottii**, side view.
Fig. 2. **Pterophorus elliottii**, top view.
Fig. 3. **Stenoptilia exclamationis**, side view.*
Fig. 4. **Stenoptilia exclamationis**, top view.*
Fig. 5. **Platyptilia albidorsella**, side view.
Fig. 6. **Platyptilia albidorsella**, top view.
Fig. 7. **Platyptilia albidorsella**, end view of uncus.
Fig. 8. **Platyptilia tesseradactyla**, side view.
Fig. 9. **Platyptilia tesseradactyla**, top view.
Fig. 10. **Platyptilia albida**, side view.
Fig. 11. **Platyptilia albida**, top view.
Fig. 12. **Platyptilia albicans**, side view.
Fig. 13. **Platyptilia albicans**, top view.
Fig. 14. **Platyptilia percnodactyla**, side view.
Fig. 15. **Platyptilia percnodactyla**, top view.

---

* The uncus is wanting in the specimens from which these drawings were made.

Plate VIII.

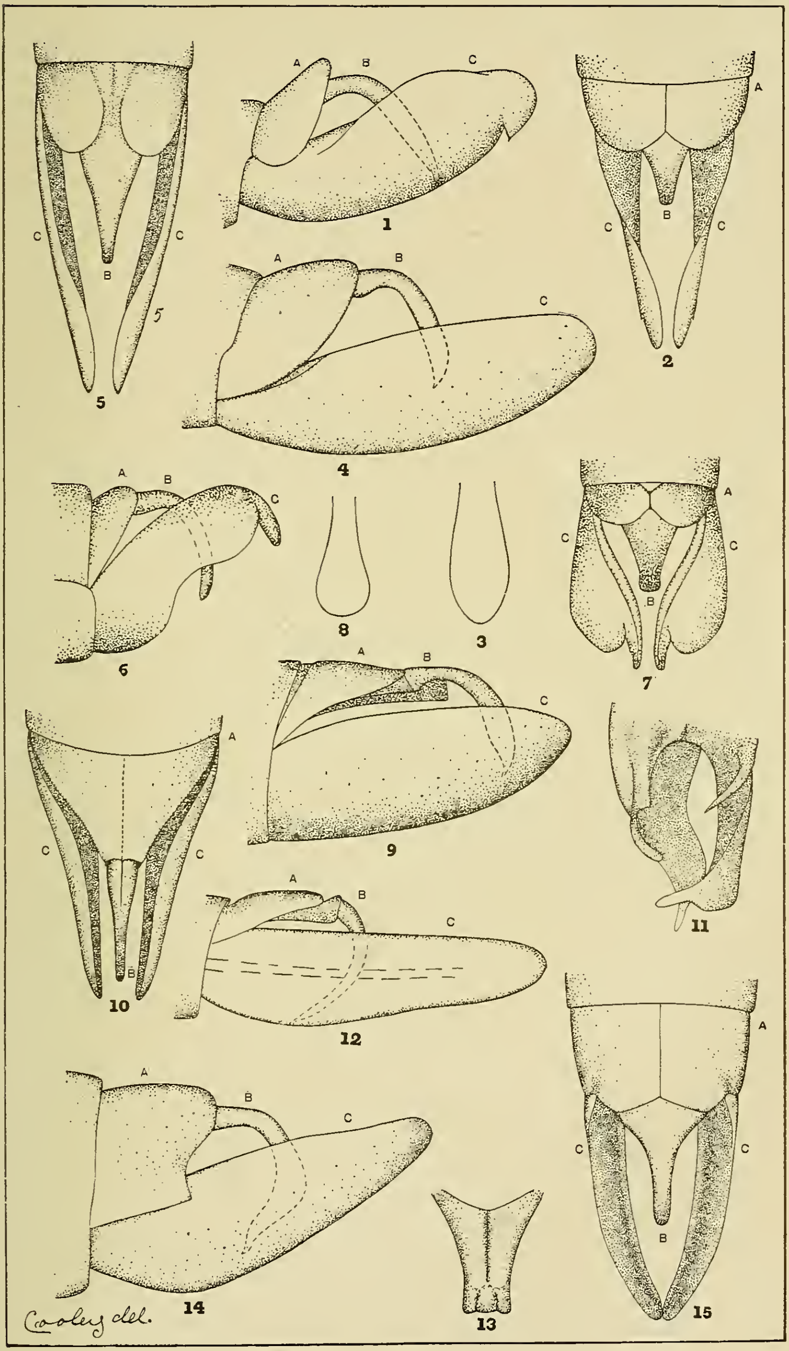

A
B
C
1
A
C
C
B
2
A
C
3
A
C
C
4
A
B
C
5
A
C
C
B
6
A
C
C
B
11
A
B
C
8
A
B
C
12
A
B
C
C
9
7
A
C
C
B
13
A
B
C
14
A
C
C
B
15
A
B
C
10
Cooley del.

Explanation of Plate IX.

MALE GENITALIA OF PTEROPHORIDÆ.

Fig. 1. **Platyptilia cosmodactyla**, side view.
Fig. 2. **Platyptilia cosmodactyla**, top view.
Fig. 3. **Platyptilia cosmodactyla**, end of uncus.
Fig. 4. **Platyptilia marginidactyla**, side view.
Fig. 5. **Platyptilia marginidactyla**, top view.
Fig. 6. **Platyptilia albiciliata**, side view.
Fig. 7. **Platyptilia albiciliata**, top view.
Fig. 8. **Platyptilia albiciliata**, end of uncus.
Fig. 9. **Alucita cinerascens**, side view.
Fig 10. **Alucita cinerascens**, top view.
Fig. 11. **Alucita cinerascens**, view of an internal chitinous piece.
Fig. 12. **Pterophorus guttatus**, side view.
Fig. 13. **Pterophorus guttatus**, top view of dorsal plate.
Fig. 14. **Platyptilia ochrodactyla**, side view.
Fig. 15. **Platyptilia ochrodactyla**, top view.

Plate IX.


5
C
C
B
A
B
C
1
A
C
B
C
2
4
A
B
C
A
B
C
6
8
3
A
C
C
B
7
9
A
B
C
A
C
C
B
10
11
A
B
C
12
A
14
A
B
C
13
C
C
B
15
Cooley del.

INDEX OF GENERA.

PAGE
Aciptilus, . . 97, 117, 118, 119
Alucita, ... 117
Alucita, . 106, 107, 114, 121, 122, 130, 132, 138, 140
Amblyptilus, ... 105, 106
Leioptilus, ... 121, 125
Lioptilus, . 121, 123, 124, 125, 127, 128, 130
Mimeseoptilus, ... 137, 139
Œdematophorus, 131, 132, 133, 134, 135

PAGE
Orneodes, ... 140
Oxyptilus, ... 98
Platyptilia, ... 104
Platyptilus, . 107, 108, 109, 110, 111, 112, 113, 115
Pterophorus, ... 119
Pterophorus, . . 97, 99, 102, 108, 112, 115
Stenoptilia, ... 136
Trichoptilus, ... 95

INDEX OF SPECIES.

PAGE
acanthodactyla, ... 107
adusta, ... 113
adustus, ... 113
agraphodactylus, ... 127
albicans, ... 113
albiciliata, ... 113
albiciliatus, ... 113
albida, ... 111
albidorsella, ... 111
albidorsellus, ... 111
albidus, ... 111
ambrosiæ, ... 135
angustus, ... 124
baroni, ... 133
belfragei, ... 117
bertrami, ... 115
bischoffii, ... 115
californicus, ... 97
cardui, ... 108
carduidactyla, ... 108
carduidactylus, ... 108
cervinidactylus, ... 115
cineraceus, ... 133
cinerascens, ... 119
cineridactylus, ... 130
cosmodactyla, ... 106

PAGE
cosmodactylus, ... 106
cretidactylus, ... 131
cretidactylus, ... 132
delavaricus, ... 102
delawaricus, ... 100
edwardsii, ... 107
elliottii, ... 122
eupatorii, ... 132
exclamationis, ... 139
fishii, ... 121
fragilis, ... 110
grandis, ... 111, 130
gratiosus, ... 134
grisescens, ... 135
guttatus, ... 133
helianthi, ... 123
hexadactyla, ... 140
hololeucos, ... 121
homodactylus, ... 121
inconditus, ... 127
inquinatus, ... 135
kellicottii, ... 128
lacteodactylus, ... 123
lobidactylus, ... 97
lugubris, ... 134
marginidactyla, ... 115

PAGE

marginidactylus, ... 115
mathewianus, ... 125
modesta, ... 112
modestus, ... 112
monodactyla, ... 130
monodactylus, ... 130
montana, ... 118
montana, ... 140
montanus, ... 118
naevosidactylus, ... 130
nebulaedactylus, ... 115
nigrociliatus, ... 102
ningoris, ... 101
occidentalis, ... 131
ochrodactylus, ... 96
orthocarpi, ... 110
paleaceus, ... 125
parvus, ... 128
pergracilidactylus, ... 130

PAGE

percnodactyla, ... 109
percnodactylus, ... 109
periscelidactylus, ... 99
petrodactyla, ... 112
petrodactylus, ... 112
pica, ... 105
pterodactyla, ... 138
pumilio, ... 137
pygmaeus, ... 96
semicostata, ... 139
semicostatus, ... 139
sericidactylus, ... 125
shastæ, ... 109
stramineus, ... 124
subochraceus, ... 123
sulphureodactylus, ... 124
sulphureus, ... 124
tenuidactylus, ... 102
tesseradactyla, ... 114

TENTH ANNUAL REPORT

OF THE

HATCH EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE.

JANUARY, 1898.

HATCH EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE,

AMHERST, MASS.

By act of the General Court, the Hatch Experiment Station and the State Experiment Station have been consolidated under the name of the Hatch Experiment Station of the Massachusetts Agricultural College. Several new divisions have been created and the scope of others has been enlarged. To the horticultural has been added the duty of testing varieties of vegetables and seeds. The chemical has been divided, and a new division, "Foods and Feeding," has been established. The botanical, including plant physiology and disease, has been restored after temporary suspension.

The officers are : —

Henry H. Goodell, LL.D.,	*Director.*
William P. Brooks, Ph.D.,	*Agriculturist.*
George E. Stone, Ph.D.,	*Botanist.*
Charles A. Goessmann, Ph.D., LL.D.,	*Chemist* (fertilizers).
Joseph B. Lindsey, Ph.D.,	*Chemist* (foods and feeding).
Charles H. Fernald, Ph.D.,	*Entomologist.*
Samuel T. Maynard, B.Sc.,	*Horticulturist.*
J. E. Ostrander, C.E.,	*Meteorologist.*
Henry M. Thomson, B.Sc.,	*Assistant Agriculturist.*
Ralph E. Smith, B.Sc.,	*Assistant Botanist.*
Henri D. Haskins, B.Sc.,	*Assistant Chemist* (fertilizers).
Charles I. Goessmann, B.Sc.,	*Assistant Chemist* (fertilizers).
George D. Leavens, B.Sc.,	*Assistant Chemist* (fertilizers).
Edward B. Holland, B.Sc.,	*Assistant Chemist* (foods and feeding).
Fred W. Mossman, B.Sc.,	*Assistant Chemist* (foods and feeding).
Benjamin K. Jones, B.Sc.,	*Assistant in Foods and Feeding.*
Robert A. Cooley, B. Sc.,	*Assistant Entomologist.*
G. A. Drew, B. Sc.,	*Assistant Horticulturist.*
H. D. Hemenway, B.Sc.,	*Assistant Horticulturist.*
H. H. Roper, B.Sc.,	*Assistant in Foods and Feeding.*
A. C. Monahan,	*Observer.*

The co-operation and assistance of farmers, fruit growers, horticulturists and all interested, directly or indirectly, in agriculture, are earnestly requested. Communications may be addressed to the "Hatch Experiment Station, Amherst, Mass."

The following bulletins are still in stock and can be furnished on demand: —

No. 27. Tuberculosis in college herd; tuberculin in diagnosis; bovine rabies; poisoning by nitrate of soda.
No. 28. Canker, army and corn worms; red-humped apple-tree caterpillar; antiopa butterfly; currant stem girdler; imported elm-bark louse; greenhouse orthezia.
No. 29. Fungicides and insecticides; new spraying pump; spraying calendar.
No. 33. Glossary of fodder terms.
No. 35. Agricultural value of bone meal.
No. 36. Imported elm-leaf beetle; maple pseudococcus; abbot sphinx; San José scale.
No. 37. Report on fruits, insecticides and fungicides.
No. 38. Fertilizer analyses; composition of Paris green; action of muriate of potash on the lime resources of the soil.
No. 41. On the use of tuberculin (translated from Dr. Bang).
No. 42. Fertilizer analyses; fertilizer laws.
No. 43. Effects of electricity on germination of seeds.
No. 44. Variety tests of fruits; tests of vegetable seeds.
No. 45. Commercial fertilizers; fertilizer analyses; fertilizer laws.
No. 46. Habits, food and economic value of the American toad.
No. 47. Field experiments with tobacco.
No. 48. Fertilizer analyses.
No. 49. Fertilizer analyses.
Special bulletin, — The brown-tail moth.
Index, 1888–95.

Of the other bulletins, a few copies remain, which can only be supplied to complete sets for libraries.

The work during the year has been unusually diversified in its character and importance, a result of the numerous problems sent in for solution. In the agricultural division, soil tests with corn and potatoes grown in several localities have been continued; a comparison of different fertilizers has been made; "Nitragin" has again been tried, with negative results; and an interesting test has been carried on of twenty varieties of corn, eighty-one of potatoes, sixty of grasses, twenty-one of millets and four of clover.

In the division of chemistry (fertilizers), aside from the six hundred analyses of licensed fertilizers and manurial substances, valuable work has been done for the tobacco-growers of the Connecticut valley in the analyses of tobacco leaves grown with different fertilizers, testing of the quality of ash and burning quality, and suggestions as to methods of planting, fertilizers to be employed and mechanical preparation of the soil.

In the botanical division, investigations have been carried on of the brown rot of stone fruit, the chrysanthemum rust, the leaf blights of certain native trees, as the sycamore, butternut, chestnut and black cherry, with recommendations of treatment for the brown rot and chrysanthemum rust.

The horticultural division has continued its work of testing varieties of fruit and seeds of vegetables, and has entered upon an investigation of the use of hydrocyanic acid as an insecticide.

From the entomological division have issued two important bulletins on the habits, food and economic value of the American toad and the brown-tail moth. A monograph on the plume-moths (some varieties of which attack plants of economic value and those raised for ornamental purposes) has been completed. The superiority of spraying for the canker worm over ink bands and oil troughs has been demonstrated, and investigations carried on of new insecticides with which to assail the gypsy moth.

A series of observations for the electrical determination of moisture in the soil, in connection with the growth of corn, were undertaken by the meteorological division. Owing to breaks in the circuit and other causes that made the instrument fail to work, and the abnormally wet weather of the summer, the results were not entirely satisfactory, and the observations will be repeated the coming season.

Three investigations in the division of foods and feeding are worthy of special note: (*a*) On the comparative values of corn meal and hominy and cerealine feeds for pork production, when fed in combination with skim-milk. It was found that the pigs did quite as well on these feeds as on an equal amount of corn meal. (*b*) On salt-marsh hay. It was found to possess less feeding value than English hay, but, combined with grain and ensilage, produced nearly as much milk and butter as an equal amount of English hay thus combined. (*c*) On cotton-seed feed as a hay substitute for milch cows. More energy was used up in its digestion than in hay, and it was concluded that Massachusetts farmers would derive no benefit from feeding this material in place of hay.

Reports of the different divisions, giving in detail the work of the year, accompany this brief summary.

ANNUAL REPORT

Of George F. Mills, *Treasurer* of the Hatch Experiment Station of Massachusetts Agricultural College,

For the Year ending June 30, 1897.

Cash received from United States treasurer,		$15,000 00
Cash paid for salaries,	$5,087 75	
for labor,	3,312 26	
for publications,	2,354 06	
for postage and stationery,	264 11	
for freight and express,	245 78	
for heat, light and water,	193 31	
for seeds, plants and sundry supplies,	600 55	
for feeding stuffs,	185 11	
for library,	1,139 85	
for tools, implements and machinery,	272 21	
for furniture and fixtures,	33 43	
for scientific apparatus,	226 83	
for live stock,	125 45	
for travelling expenses,	352 32	
for contingent expenses,	42 73	
for building and repairs,	564 25	
		$15,000 00

Cash on hand July 1, 1896,	$1,042 92	
Received from State treasurer,	10,000 00	
from fertilizer fees,	4,087 75	
from farm products,	1,934 15	
from miscellaneous sources,	1,022 19	
		$18,087 01
Cash paid for salaries,	$10,784 83	
for labor,	1,075 81	
for publications,	175 03	
for postage and stationery,	156 18	
for freight and express,	187 48	
for heat, light and water,	361 64	
Amount carried forward,	$12,740 97	

Amount brought forward,	$12,740 97	
Cash paid for chemical supplies,	592 48	
for seeds, plants and sundry supplies,	515 54	
for fertilizers,	1,074 41	
for feeding stuffs,	559 24	
for library,	61 82	
for tools, implements and machinery,	28 62	
for furniture and fixtures,	176 12	
for scientific apparatus,	357 48	
for live stock,	359 45	
for travelling expenses,	72 72	
for contingent expenses,	273 03	
for building and repairs,	1,255 40	
Cash on hand June 30, 1897,	19 73	
		$18,087 01

AMHERST, MASS., Aug. 30, 1897.

I, Charles A. Gleason, duly appointed auditor of the corporation, do hereby certify that I have examined the books and accounts of the Hatch Experiment Station of the Massachusetts Agricultural College for the fiscal year ending June 30, 1897; that I have found the books well kept and the accounts correctly classified as above; and that the receipts for the year are shown to be $33,087.01, and the corresponding disbursements $33,067.28. All the proper vouchers are on file and have been by me examined and found to be correct, there being a balance of $19.73 on accounts of the fiscal year ending June 30, 1897.

CHARLES A. GLEASON,
Auditor.

REPORT OF THE AGRICULTURIST.

WILLIAM P. BROOKS.

Soil Tests.

Four soil tests upon the plan heretofore followed were attempted during the past year; viz., with corn in Norwell and Montague, with potatoes and with onions (and later cabbages) upon our home grounds. Only the tests in Norwell and with potatoes upon our home grounds were successfully carried through.

Unfavorable weather conditions destroyed the onions and cabbages upon our south soil-test acre. The field was sown to white mustard late in July. But four plots furnished sufficient growth to cut and weigh; viz., lime plot, 1 pound; manure plot, 425 pounds; nitrate and dissolved bone-black, 45 pounds; potash and dissolved bone-black, 25 pounds; nitrate, dissolved bone-black and potash plot, 255 pounds,—all green weights.

The field has now been used nine years in soil-test work, and we have a high degree of one-sided exhaustion on most of the plots. The close dependence of the mustard upon a supply of phosphoric acid (furnished by the bone-black) is brought out, as was the case in 1895; but phosphoric acid alone can no longer produce any growth of mustard upon this soil. The addition of either nitrogen or potash helps it, the former most; but not much growth is produced unless all three are supplied.

The soil test with corn in Montague was ruined by wire and cut worms. As nearly as could be determined from the portion of the crop left, nitrogen seemed the most necessary element upon this soil.

1. *Soil Test with Corn. Norwell.*

This is the second year of soil-test work in this field, the crop last year also being corn. Last year potash was the controlling element; the result this year is the same. Muriate of potash, at the rate of 160 pounds per acre, gives an average increase at the rate of 36.3 bushels of grain and 2,203 pounds of stover; nitrate of soda, at the same rate per acre, gives an average increase of 8.3 bushels of grain and 325 pounds of stover; dissolved bone-black, at the rate of 320 pounds per acre, gives an average increase of 15.3 bushels of grain and 455 pounds of stover. Five cords of manure increase the crop by 26.4 bushels of grain and 3,450 pounds of stover per acre; complete fertilizer (nitrate, dissolved bone-black and potash at above rates) gives an increase of grain 52.5 bushels and stover 2,455 pounds; lime and plaster both produce apparent small increases.

2. *Soil Test with Potatoes. Amherst.*

The field upon which this test was carried out lies upon our own grounds. It has a medium, well-drained loam, and has been seven years in soil-test experiments. The crops in order of succession have been potatoes, corn, soya beans, oats, grass and clover (two years), and cabbages and Swedish turnips. This year the phosphoric acid gives the largest average increase in crop, viz., at the rate of 26.6 bushels of merchantable tubers per acre; nitrogen gives an increase of 11.3 bushels merchantable tubers and potash an increase of 7.2 bushels. The soil, however, is very generally exhausted, and no single fertilizer or combination of either two or all three gave a good crop. The apparent superiority of the phosphoric acid and nitrogen is chiefly due to the fact that the plot to which those two elements alone were applied was for some reason (not believed to be the effect of the fertilizer alone) nearly twice as great as that upon any other plot. Had the crop where the potash was added to the nitrogen and phosphoric acid been better or even as good as that where the phosphoric acid and nitrogen alone were used, we should be justified in the conclusion that the nitrogen and phosphoric acid are the elements chiefly required. The crop where all three elements were combined was, however, much inferior to that where the nitrogen and phosphoric acid were used without potash. We must therefore conclude that some disturbing factor, at present unknown, influenced the results; and we are, therefore, unable to draw practical conclusions which throw light upon the proper practice to be followed in manuring the potato crop.

Manure Alone v. Manure and Potash.

An experiment in continued corn culture for the comparison of an average application of manure with a small application of manure used in connection with muriate of potash was begun in 1890. A full account of the results will be found in the annual reports of 1890–95, and in the latter year a general summary of the results is given.

The land used in this experiment was seeded with a mixture of timothy, red-top and clover in the standing corn in July of last year. A good stand of grass and clover was secured, although the latter was rather unevenly developed in different parts of the field, suggesting a possible lack of thoroughness in mixing the seeds.

No manure or potash has been used this year. The field includes four plots of one-fourth of an acre each. The results for 1897 are shown below: —

Plot 1 (1½ cords of manure alone, 1890–96): hay, 1,420 pounds; rowen, 783 pounds.

Plot 2 (1 cord manure and 40 pounds of muriate of potash, 1890–96): hay, 885 pounds; rowen, 483 pounds.

Plot 3 (manure alone, as for Plot 1): hay, 1,380 pounds; rowen, 785 pounds.

Plot 4 (manure and potash, as for Plot 2): hay, 1,037½ pounds; rowen, 590 pounds.

The averages are as follows: —

Plots 1 and 3 (manure alone, 1890–96): hay, 1,403½ pounds; rowen, 784 pounds.

Plots 2 and 4 (manure and potash, 1890–96): hay, 961¼ pounds; rowen, 536½ pounds.

Combining the figures showing the averages of hay and rowen, we find that plots 1 and 3 have produced an average of 2,187 pounds per plot, which is at the rate of 4 tons, 748 pounds, per acre. Plots 2 and 4 have produced an average of 1,497¼ pounds per plot, which is at the rate of 9 pounds less than 3 tons per acre. The larger quantity of manure, then, produced this year about 1⅓ tons more per acre than the manure and potash. This is a large difference, but a difference which was to be anticipated, in view of the much larger quantity of plant food which has been applied to these plots. It remains to be seen whether the clover on plots 2 and 4 will be capable of so enriching the soil in nitrogen as to remove or lessen this difference in succeeding years.

"Special" Corn Fertilizer v. Fertilizer richer in Potash.

This experiment was begun with a view of comparing the results obtained with a fertilizer proportioned like the average of the "*special*" *corn fertilizers* found upon our markets in 1891 with those obtained with a fertilizer richer in potash but furnishing less nitrogen and phosphoric acid.

Corn was grown during each of the years from 1891 to 1896 inclusive. From 1891 to 1895 it was found that the fertilizer richer in potash gave the more profitable results. In 1896 there was no practical difference. It was decided during the season of 1896 that it might be possible to derive a greater benefit from the larger quantity of potash applied to two of the four plots if grass and clover should be grown in rotation with the corn. Accordingly the land was seeded with a mixture of timothy, red-top and clover in the standing corn in July, 1896. The field is divided into four plots, of one-fourth of an acre each. The materials applied to the several plots are shown in the following table: —

FERTILIZERS.	Plots 1 and 3 (Pounds each).	Plots 2 and 4 (Pounds each).
Nitrate of soda,	20	18
Dried blood,	30	30
Dry ground fish,	30	20
Plain superphosphate,	226	120
Muriate of potash,	22.5	60
Cost of materials per plot,	$3 23	$3 10

Fertilizers were applied evenly broadcast on April 11. The yields the past year are shown below: —

Plot 1, "special" fertilizer: hay, 795 pounds; rowen, 130 pounds.

Plot 2, fertilizer richer in potash: hay, 810 pounds; rowen, 129 pounds.

Plot 3, "special" fertilizer: hay, 725 pounds; rowen, 97 pounds.

Plot 4, fertilizer richer in potash: hay, 617 pounds; rowen, 165 pounds.

The average yield on plots 1 and 3 is: hay, 760 pounds; rowen, 113½ pounds. On plots 2 and 4: hay, 713½; rowen, 147 pounds. Putting the crops of hay and rowen together, we have an average from 1 and 3 of 873½ pounds, and from 2 and 4 of 860½ pounds. The difference, 13 pounds, is too small to be regarded as of much significance. The greater rowen crop produced by plots 2 and 4 is perhaps to be attributed to the larger amount of potash which has been applied to these plots, which favors especially the growth of the clovers. Inequality of moisture conditions, however, has been the apparent cause of a very uneven development of clover on different parts of the field, and the influence of the potash does not show as clearly as was anticipated.

NATURAL PHOSPHATES COMPARED WITH EACH OTHER AND WITH ACID PHOSPHATE. (FIELD F.)

This series of experiments was begun by Dr. Goessmann in 1890, with a view of determining whether it is not more profitable to employ one of the cheaper natural phosphates than to use the more costly acid phosphate. A full account of the experiment and the results obtained up to the end of 1896 is given by Dr. Goessmann in our ninth annual report. It is only necessary to restate the following points: —

The field was at first divided into five plots, containing about 6,600 square feet each. These plots received equal money's worth (on the basis of prices in 1890) of the phosphates used, as follows: Plot 1, phosphatic slag; Plot 2, Mona guano; Plot 3, at first, apatite; later, Florida phosphate; Plot 4, South Carolina phosphate; Plot 5, dissolved bone-black. Plot 3, as above stated, received an application of ground apatite in 1890. In 1891 it was found impossible to obtain this material, and no phosphate of any kind was applied to this plot. In 1892 and 1893 ground hard Florida phosphate was applied to this plot. It is not believed, however, that it is fair to this phosphate to compare it with the others, since it has been used only two years, while the others have been applied for four years.

From the beginning, each of these five plots has received the same application of nitrate of soda and potash-magnesia sulphate. The quantities of these applied per plot during the first four years were about 44 pounds of the former and 66 pounds of the latter.*

Since 1894 no phosphate of any kind has been applied to these plots, but the quantity of nitrate of soda and of potash-magnesia sulphate has been used in one-half greater quantities.

At first Dr. Goessmann included no plot on which phosphate was not used for comparison with others. Later such a plot was added, but it was left entirely unmanured until 1896. During 1896 and 1897 it has received the nitrate of soda and potash-magnesia sulphate at the same rate as the other plots.

---

* The plots in this experiment differ from each other by a few square feet in size, and the fertilizers have from the beginning varied in proportion as the size varied.

The yield of the plots receiving phosphate for each of the years 1890–96 inclusive will be found in our ninth annual report. This report also contains a statement showing the amounts of phosphoric acid applied and removed from each plot during each of these years. This statement shows an excess added over and above that removed from each of the plots at the end of the season of 1896 as follows: where phosphatic slag had been used, the amount of phosphoric acid remaining was 65.6 pounds; where Mona guano had been used, 44.2 pounds; where apatite and Florida phosphate had been used, 141.7 pounds; where South Carolina rock phosphate had been used, 115.0 pounds; and where acid phosphate had been used, 21.8 pounds.

The crop during the past year was Swedish turnips. The field had been sown with rye for winter protection in the fall of 1896. The growth of the rye was characterized as poor. It was ploughed on June 1, the land was harrowed on the 2d, and on the 3d of June, Laing's Swedes were sown in drills two feet apart. The seed germinated promptly and evenly, but the season was much too wet for the best growth of the crop. It was, however, kept free from weeds by frequent cultivation. The crop was thinned on June 20 to eight inches. It was harvested November 2–4. The turnips were poor in quality, small, and a few of them decayed.

The yields of the several plots were as follows: —

	Roots (Pounds).	Tops (Pounds).
Plot 0, no phosphate, ...	830	185
Plot 1, phosphatic slag, ...	1,870	480
Plot 2, Mona guano, ...	3,655	800
Plot 3, Florida hard phosphate, . . .	820	400
Plot 4, South Carolina rock phosphate, .	1,965	560
Plot 5, dissolved bone-black, . . .	1,619	370

It will be noticed that the crop on the phosphatic slag, Mona guano and South Carolina rock surpasses that where dissolved bone-black was used, and that the Mona guano gives nearly twice the product obtained by either the slag or the South Carolina rock. It will be further noticed that the Florida phosphate yields practically the same amount of roots as the plot receiving no phosphate. None of the crops secured this year can be regarded as good. The largest yield, that on the Mona guano plot, is at the rate of rather less than 12 tons per acre. A good crop should be about 20 tons per acre. The results of this year, therefore, although showing marked differences, are not regarded as decisive. The peculiarities of the season produced an unhealthy condition, which interfered with the full action of the fertilizers employed.

COMPARISON OF DIFFERENT PHOSPHATES.

The results of the experiments inaugurated by Dr. Goessmann for the comparison of different phosphates with acid phosphate having proved so interesting and valuable, it was decided to inaugurate another series of experiments, including a greater number of materials supplying phosphoric acid. It was further thought best to apply these materials upon the basis of equal quantities of phosphoric acid to each plot, rather than on the basis of equal money's worth, as in the experiments planned by Dr. Goessmann.

The land selected for the experiment was fairly level, with a medium heavy loam. It had been in grass for many years. In April, 1896, it received an application of 600 pounds of ground bone and 200 pounds of muriate of potash per acre. The season was very dry, and the grass derived little benefit from the fertilizers. The grass was cut about the middle of June, and the field was ploughed on June 24 and 25, 1896, and planted to Longfellow corn. The corn was cut when in the milk, September 26, and weighed as put into the silo. The field had been divided into 13 plots, of one-eighth of an acre each, separated by suitable unmanured strips. The yields of corn in 1896 were as follows: —

Plot 1, 2,640 pounds; Plot 2, 2,990 pounds; Plot 3, 2,915 pounds; Plot 4, 3,555 pounds; Plot 5, 2,885 pounds; Plot 6, 2,905 pounds; Plot 7, 2,850 pounds; Plot 8, 3,020 pounds; Plot 9, 3,160 pounds; Plot 10, 3,095 pounds; Plot 11, 3,000 pounds; Plot 12, 3,090 pounds; Plot 13, 3,440 pounds.

These weights were taken with a view to determining whether these plots were fairly even in fertility. It will be noticed that with three exceptions, plots 1, 4 and 13, this appears to be the case. Plot 1 is apparently poorer than the average, while plots 4 and 13 are better.

In 1897 the soil was thoroughly prepared by the use of the wheel harrow. Fertilizers were applied May 11. Each plot in the field received the following materials: potash-magnesia sulphate, 50 pounds; nitrate of soda, 30¼ pounds; sulphate of potash, high grade, 12½ pounds. These materials supplied the potash and nearly all the nitrogen estimated to be required. Some of the phosphates to be employed (the bone meals), however, contained nitrogen as well as phosphoric acid, and, to equalize conditions on all the plots, sufficient hoof meal was applied to those not receiving bone to make the quantity of nitrogen applied to each plot throughout the field the same.

The plots contained, as stated, one-eighth of an acre each, and the materials used furnished to each plot phosphoric acid, 12 pounds; nitrogen, 6½ pounds; potash, 19 pounds.

The fertilizers used per plot (in addition to nitrate of soda and sulphate of potash which were used alike on each as stated above) are shown below: —

Plot 1: hoof meal, 11¾ pounds. Plot 2: hoof meal, 11¾ pounds; apatite, 32 pounds. Plot 3: hoof meal, 11¾ pounds; South Carolina rock phosphate, 47 pounds. Plot 4: hoof meal, 11¾ pounds; Florida soft phosphate, 45½ pounds. Plot 5: hoof meal, 11¾ pounds; slag, 67¼ pounds. Plot 6: hoof meal, 11¾ pounds; Navassa phosphate, 49 pounds. Plot 7: hoof meal, 11¾ pounds. Plot 8: hoof meal, 11¾ pounds; dissolved bone-black, 70 pounds. Plot 9: hoof meal, $\frac{6}{16}$ pound; raw bone meal, 45 pounds. Plot 10: hoof meal, $1\frac{3}{16}$ pounds; dissolved bone meal, 73¼ pounds. Plot 11: steamed bone meal, 48¼ pounds. Plot 12: hoof meal, 11¾ pounds; acid phosphate, 90½ pounds. Plot 13: hoof meal, 11¾ pounds.

The variety of corn raised was Sibley's Pride of the North, which was planted on May 17, replanted as far as necessary on June 1, and thinned to one plant per foot in the drill early in June. The extraordinary precipitation of the season kept the soil too wet the greater part of the time during the month of July, and the crop was prevented from doing its best. It was cut and stooked September 21, and husked about the last of October.

The yield per plot and the calculated rates per acre are shown below: —

NAMES.	Corn (Pounds).	Stover (Pounds).	Corn per Acre (Bushels).	Stover per Acre (Pounds).
Plot 1, no phosphate, . . .	585	580	58.500	4,640
Plot 2, apatite, ...	565	475	56.500	3,800
Plot 3, South Carolina rock phosphate	645	535	64.500	4,280
Plot 4, Florida soft phosphate, .	725	620	72.500	4,960
Plot 5, phosphatic slag, . .	620	620	62.000	4,960
Plot 6, Navassa phosphate, . .	678¼	610	67.825	4,880
Plot 7, no phosphate, . . .	643¼	542	64.325	4,336
Plot 8, dissolved bone-black, .	618¼	548	61.825	4,384
Plot 9, raw bone meal, . . .	673¼	570	67.325	4,560
Plot 10, dissolved bone meal, .	633¼	550	63.325	4,400
Plot 11, steamed bone meal, . .	503¼	450	50.325	3,600
Plot 12, acid phosphate, . .	628¼	540	62.825	4,320
Plot 13, no phosphate, . . .	673¼	590	67.325	4,720

It will be noticed that one of the best crops in the field was produced where no phosphate was used, and that the yield on the plots to which phosphates were applied varies without apparent relation to the availability of the phosphoric acid in the materials used. Under these circumstances, extended discussion of the results is not called for.

The unfavorable influence of the season and possible differences in natural fertility of the soil serve to obscure the action of the phosphates employed.

LEGUMINOUS CROPS (CLOVER, PEA AND BEAN, OR "POD" FAMILY) AS NITROGEN GATHERERS. (FIELD A.)

A full history of the field since 1884 is given by Dr. Goessmann in our ninth annual report. The years 1884–88 were preparatory; the experiment proper began in 1889. The objects in view have been: —

1. To determine the extent to which plants of the clover family are capable of enriching the soil in nitrogen taken by them from the air through the agency of the nodular bacteria found upon their roots.

2. To compare nitrate of soda, sulphate of ammonia, dried blood and barn-yard manure as sources of nitrogen.*

The field is divided into eleven $\frac{1}{10}$ acre plots, numbered from 0 to 10. Three plots, 4, 7 and 9, have received no application of nitrogen-containing manure or fertilizer since 1884. One (0) has received barn-yard manure; two (1, 2), nitrate of soda; three (5, 6, 8), sulphate of ammonia; and two (3, 10), dried blood every year since 1889. These materials have been used in such amounts as to furnish nitrogen at the rate of 45 pounds per acre each year. All the plots have received, yearly, equal amounts of phosphoric acid and potash. The quantities applied have furnished, per acre, phosphoric acid 80 pounds, and potash 125 pounds, from 1889 to 1894 and the past season. In 1895 and 1896 double these quantities were used. Dr. Goessmann reports: † —

> The total yield of crops on the plots receiving no nitrogen, as compared with those receiving nitrogen, was in the several years as follows: —
>
> With corn in 1889, one-fifth less.
> With oats in 1890, one-fifth to one-sixth less.
> With rye in 1891, one-fifth to one-sixth less.
> With soya beans in 1892, one-third to one-fourth less.

---

* Only such details are given here as are necessary to a general understanding of the subject; full information is found, as stated above, in our ninth annual report.

† Ninth annual report, Hatch Experiment Station, page 175.

In 1893 the crop was oats, and the yield of grain was from one-seventh to one-eighth less on the plots receiving no nitrogen than the average of those receiving nitrogen. Here the interposition of a leguminous crop (soya bean in 1892) appears to have lessened the proportional inferiority of the plots which received no nitrogen. In 1894 the crop was again the soya bean. The plots without nitrogen give a yield about one-third less than the average of the others. Thus far it will be seen that the soya bean has not shown that degree of independence of soil nitrogen of which it is supposed to be capable. To an even greater degree than the grain crops it is benefited by nitrogen manuring. This fact may perhaps be accounted for because of conditions unfavorable to bacterial life in this soil; but as to the nature of such unfavorable conditions we are at present ignorant.

In 1895 the crop was oats, and results showed no improvement in proportional yield on the plots receiving no nitrogen which could be attributed to the preceding bean crop. This may be in part due to the fact that the bean has a rather limited root system, and leaves behind but little stubble.

In 1896 the crop was again the soya bean, which once more showed marked inferiority on the no-nitrogen plots. An attempt to seed the land to clover in the standing beans proved a failure, on account of the dry season and the too dense shade made by the crop of beans.

The crop the past season has been oats. The yield per plot of straw and grain, the rate per acre and remarks upon the quality of the grain are given below. In this table the no-nitrogen plots are italicised.

Nitrogen Experiment.

PLOT.	Weight per Plot One-tenth Acre.		Yield per Acre.		Remarks on Grain.
	Straw (Pounds).	Oats (Pounds).	Straw (Pounds).	Oats (Bushels).	Kernels.
Nitrate of soda,	500	159	5,000	49.68	Light.
Nitrate of soda,	400	147	4,000	45.93	Light.
Dried blood,	215	122	2,150	38.12	Good.
No nitrogen,	*120*	*69*	*1,200*	*21.56*	Good.
Sulphate of ammonia,	340	137	3,400	42.81	Poorer than No. 3.
Sulphate of ammonia,	275	97	2,750	30.31	Good.
No nitrogen,	*120*	*77½*	*1,200*	*24.21*	Good.
Sulphate of ammonia,	350	127	3,500	39.68	Good.
No nitrogen,	*130*	*75*	*1,300*	*23.43*	Good.
Dried blood,	220	126	2,200	39.37	Fair.
Barn-yard manure,	220	125	2,200	39.06	Fair.

Calculation shows that the average total weight of crop is a little less than one-half as great on the plots not manured with nitrogen as the average of the other plots. The crop of grain is a little more than one-half as great. We find, then, not the least evidence of any ability on the part of the soya bean when grown before a grain crop (and harvested) to make nitrogen manuring of the grain crop unnecessary. On the contrary, the proportional yield of the no-nitrogen plots is this year the lowest it has ever been in these experiments.

The Relative Value of the Different Manures furnishing Nitrogen.

The nitrate of soda gives the largest crop. Next in order of yield come the barn-yard manure, dried blood and sulphate of ammonia; but between these there is not much difference. On plots 2, 3, 4, 6, 7, 8 and 9 the source of potash is the muriate; on all others it is double sulphate of potash-magnesia. The yield of oats is in every instance greater where the sulphate is used under otherwise similar manuring. The superiority is most marked when sulphate of ammonia is the source of nitrogen.

MURIATE COMPARED WITH SULPHATE OF POTASH IN CONNECTION WITH SULPHATE OF AMMONIA FOR CORN.

Results obtained with different crops in the special nitrogen tests on Field A during previous years having indicated an injurious effect, due to the combination of muriate of potash and sulphate of ammonia,* it was decided to undertake experiments upon a larger scale, with the view of bringing out more clearly the significance or importance of this effect. Accordingly two plots of land of one-half acre each, lying on the east side of the highway, were set apart for this experiment. This land had previously been used in experiments to determine the relative value of phosphatic slag and ground bone as sources of phosphoric acid. These experiments were begun in 1894 and continued until 1896. The crops had been oats, corn and millet. An account of these experiments will be found in the annual reports covering the years named.

The following fertilizers were applied this year, broadcast, after ploughing, and harrowed in : —

North plot: sulphate of ammonia, 152 pounds; muriate of potash, 120 pounds; acid phosphate, 160 pounds.

South plot: sulphate of ammonia, 152 pounds; sulphate of potash, 120 pounds; acid phosphate, 160 pounds.

The fertilizers were applied May 11. The crop was planted in drills three and one-half feet apart, May 17. The variety was Sibley's Pride of the North.

The soil throughout the season was too wet for the best growth of the corn crop. The crop was harvested on September 6, and put into the silo. The yield was as follows:

---

* For a full discussion of this subject see Dr. Goessmann's paper in the annual report of the Hatch Experiment Station for 1897, pages 222 and 223.

north plot, 5,760 pounds; south plot, 5,255 pounds. The difference is too small to afford a basis for a positive judgment as to the merits of the two forms of potash applied.

FERTILIZERS FOR GARDEN CROPS.

In 1891 Dr. Goessmann began a series of experiments for the comparison of sulphate of ammonia, nitrate of soda and dried blood as sources of nitrogen for various garden crops. Sulphate of potash was employed to furnish potash. In 1892 the scope of the experiment was enlarged by including three additional plots, comparing the same materials as sources of nitrogen with muriate of potash used as a source of potash. The results of these experiments are fully discussed in Dr. Goessmann's reports. The following table shows the different fertilizers applied to the several plots: —

PLOTS.	Annual Supply of Manurial Substances.	Pounds.
Plot 1, ...	Sulplate of ammonia, . .	38
	Muriate of potash, . .	30
	Dissolved bone-black, .	40
Plot 2, ...	Nitrate of soda, . . .	47
	Muriate of potash, . .	30
	Dissolved bone-black, .	40
Plot 3, ...	Dried blood, . . .	75
	Muriate of potash, . .	30
	Dissolved bone-black, .	40
Plot 4, ...	Sulphate of ammonia, .	38
	Sulphate of potash, . .	30
	Dissolved bone-black, .	40
Plot 5, ...	Nitrate of soda, . . .	47
	Sulphate of potash, . .	30
	Dissolved bone-black, .	40
Plot 6, ...	Dried blood, . . .	75
	Sulphate of potash, . .	30
	Dissolved bone-black, .	40

The area of the plots is about one-eighth of an acre each. The fertilizers used supply at the rates per acre: phosphoric acid, 50.4 pounds; nitrogen, 60 pounds; potash, 120 pounds.

The crops raised during the past year were garden peas, beets, squashes and celery.

Garden Peas. — The land was ploughed April 19, fertilizers applied and harrowed in April 21, and the seed planted on April 22. On June 7 it was noticed that the growth of the vines on Plot 1 was distinctly inferior to that on the other plots, and it so continued throughout the season. The pods produced by the vines upon this plot were short, but well filled, as were they also upon Plot 4. The growth of vines upon plots 3 and 6 may be characterized as medium; upon plots 2 and 5 the growth was rank. The pods upon these two plots were large, but not well filled. Three pickings of peas were made. The yield of green peas, as well as of vines, is shown in the following table: —

Green Peas (Pounds).

DATE.	MURIATE OF POTASH.			SULPHATE OF POTASH.		
	Plot 1.	Plot 2.	Plot 3.	Plot 4.	Plot 5.	Plot 6.
July 12, ...	100	93	99½	165	179	195
July 19, ...	66	150	132	143	134	91
July 23, ...	11	60	49	40	30	21
	177	203	280½	348	343	307

Green Vines (Pounds).

DATE.	Plot 1.	Plot 2.	Plot 3.	Plot 4.	Plot 5.	Plot 6.
July 23, ...	102½	210	240	240	205	180

The average yield of green peas produced by the different fertilizers is shown in the following table: —

	Pounds.
Average of muriate plots, ...	220⅙
Average of sulphate plots, ...	332⅔
Average of sulphate of ammonia plots, . . .	262½
Average of nitrate of soda plots, ...	273
Average of dried blood plots, ...	293¾

It will be noticed that the sulphate of potash appeared to be distinctly superior to the muriate, that the dried blood gives a larger crop than either of the other sources of nitrogen, but that there is not a great difference between the three materials used to supply this element. The best crop is produced where sulphate of ammonia and sulphate of potash are used. The crop where nitrate of soda and sulphate of potash are used is not, however, materially inferior.

Beets. — The variety raised was the Eclipse. Fertilizers were applied as stated above, seed planted April 22, vacancies filled May 20. The growth of the beets upon Plot 1 was noticed early in the season to be distinctly inferior to that on the other plots, and before the close of the season most of the plants upon this plot were dead. On July 27 the crop was harvested. The yield of the several plots was as follows: Plot 1, 133 pounds; Plot 2, 711 pounds; Plot 3, 358 pounds; Plot 4, 448 pounds; Plot 5, 793½ pounds; Plot 6, 478 pounds.

The averages of the different fertilizers are shown below: —

	Pounds.
Average of muriate plots,	400⅔
Average of sulphate plots,	573⅙
Average of sulphate of ammonia plots,	290½
Average of nitrate of soda plots,	752¼
Average of dried blood plots,	418

It will be noticed that the sulphate of potash appears to be greatly superior to the muriate, and nitrate of soda is far ahead of sulphate of ammonia as a source of nitrogen for this crop. The best yield is produced where nitrate of soda and sulphate of potash are used together.

Squashes and Celery. — Both of these crops were failures, on account of the unfavorable weather. The celery plants, it is true, lived, but many of them made no growth. The plants were cut close to the ground on October 18, many of them being, if anything, smaller than when set. The cuttings were weighed, with the following results: Plot 1, 28½ pounds; Plot 2, 57 pounds; Plot 3, 35½ pounds; Plot 4, 28 pounds; Plot 5, 92 pounds; Plot 6, 24 pounds.

It is noticeable that here again Plot 5, where nitrate of soda and sulphate of potash were used, is the best; but even this did not produce a crop with any marketable value.

Injurious Effect of Sulphate of Ammonia and Muriate of Potash used together. — Particular attention is called to the fact that upon Plot 1, where sulphate of ammonia and muriate of potash are used together, the growth was, in the case of the peas and beets, decidedly inferior to that upon the other plots. This inferiority may undoubtedly be ascribed to the poisonous effect of the chloride of ammonia formed where these fertilizers are used together, to which Dr. Goessmann has called especial attention.

Experiments on Grass Land.

The system of manuring grass lands, planned by Dr. Goessmann and described by him in previous reports, has been continued. According to this system, the land receives one year a dressing of barn-yard manure at the rate of 8 tons per acre; the next year, wood ashes at the rate of 1 ton per acre; and the third year, ground bone 600 pounds, and muriate of potash 200 pounds, per acre.

Plot 1, which this year received ashes, gave a yield at the rate of 5,775 pounds of hay and 3,204 pounds of rowen per acre, — a total of 4 tons 979 pounds. Plot 2, which received manure applied in the fall of 1896, produced at the rate of 5,784 pounds of hay and 2,627 pounds of rowen per acre, — a total of 4 tons and 411 pounds. Plot 3, which this year received bone and potash, produced at the rate of 6,183 pounds of hay and 2,755 pounds of rowen per acre, — a total of 4 tons 938 pounds.

This system of using these different manures for grass lands in rotation has much to recommend it. It is simple, and has certainly given remarkably good crops. I believe, however, that the system would be improved by the use of a little nitrate of soda, say 150 pounds per acre, with the ashes as well as with the bone and potash.

Experiments with Nitragin, a Germ Fertilizer.

Nitragin, prepared according to the directions of Professor Nobbe, was imported at my suggestion from Germany in the summer of 1896. The material was fully described by Dr. Goessmann in our last annual report, and full directions for its use are quoted by him.

The nitragin has been tried in accordance with directions, as stated elsewhere in this report, upon crimson clover and alfalfa, without apparent benefit. It has also been tried upon common red clover. On this crop, as with the others, no difference in growth attributable to the nitragin has been noticed; and, so far as can be judged at the present time, the use of this germ fertilizer for our common clovers is not to be advised. Nitragin undoubtedly contains the germs of the appropriate nodular bacteria, — the name of Professor Nobbe is sufficient guarantee of this. The failure of the material to benefit the crop appears to be due to the fact that our soils contain the nodular bacteria of the common leguminous crops in sufficient numbers so that the addition of a few more by the use of nitragin counts for nothing. Experience in the open field in most parts of Germany and England has been similar to our own, and I believe that we may safely conclude that only when we are about to begin the culture of a leguminous crop new to a particular locality will it be found advantageous to employ nitragin. In such cases the soil lacks the appropriate nodular bacteria; nitragin furnishes these, and the result is a better growth, because the crop is enabled to make use of the free nitrogen of the air from the first, which it could not do in the absence of the proper bacteria.

SULPHATE OF IRON AS A FERTILIZER.

Sulphate of iron has been tried during the past season upon the same plots as in 1896, but this year with corn as a crop. The sulphate of iron is used at the rate of 80 pounds per acre. The crop where it was employed was a little inferior to that on the plots where it was not used. Without sulphate of iron the average yield of the plots was 58¼ pounds of corn and 163¼ pounds of stover; with sulphate of iron, 50¾ pounds of corn and 160 pounds of stover.

VARIETY TESTS.

1. *Corn.*

Twenty of the more promising varieties of corn tried for the first time last year have been given a further trial during the past season. Nine of these varieties were flint corns, as follows, named in the order of productiveness: Sanford, Longfellow, Waushakum, Giant Long White, Rhode Island White Cap, Early Canada, King Philip, Angel of Midnight, Compton's Early. The varieties of dent corn, named in order of productiveness, were Early Butler, Leaming Field, Champion White Pearl, Queen of the Prairie, Iowa Gold Mine, King of the Earlies, Sibley's Pride of the North, South Dakota White, Huron Extra Early, Wisconsin Yellow and White Cap Yellow.

Varieties the ears of which were very moist when husked are Queen of the Prairie and Huron Extra Early. Varieties which were moist are White Cap Dent, Leaming Field, Iowa Gold Mine and Champion White Pearl.

All of the varieties in these two classes are too late for culture as grain crops in this locality, though they would do for the silo.

2. *Potatoes.*

Eighty-one varieties of potatoes were cultivated for purposes of comparison.upon the general plan described in our last report (ninth). The soil was a well-drained medium loam. The fertilizers used per acre were as follows: —

	Pounds.
Nitrate of soda,	240
Acid phosphate,	400
Sulphate of potash (high grade),	250
Tankage,	240
Dried blood,	100

These materials were mixed and scattered broadly in the furrows before dropping the seed. The seed was planted April 30. May 5 the crop was somewhat injured by washing of the soil between the rows and by the excessive rainfall. The potatoes were dug September 26 to October 6. The yield was at the rate of from 115.7 to 282.4 bushels per acre. The eleven largest yields of merchantable tubers, in the order of productiveness, were given by the following varieties: Rose No. 9, Restaurant, Woodbury's White, Bliss's Triumph, Prolific Rose, Empire State, Early Maine, Dakota Red, Sir William, Early Rose and Beauty of Hebron. All of these gave a product at the rate of more than 220 bushels of merchantable tubers per acre. Again, as last year, we find the two old standard sorts, Early Rose and Beauty of Hebron, ranking among the very best. It appears doubtful whether any among all those tried are truly superior to these varieties.

Twenty-three varieties have given yields of merchantable tubers at the rate of less than 175 bushels per acre. These, in the order of inferiority, are the following: Minister, Bill Nye, Harbinger, Peerless, Jr., Livingston Banner, Burpee's Extra Early, Carmen No. 3, Dandy, Early Market, Crown Jewel, Merriman, White Star, Irish Daisy, Chance, Six Weeks, Alliance, Sunlit Star, World's Fair, Freeman, Ohio, Jr., Great Divide, Wise Seedling and Early Norther.

All of the varieties grown this year are to be examined for determination of dry matter and starch, but this work could not be completed in season for this report. Full details as to the varieties cultivated are therefore reserved until these analytical results can be published.

3. *Grasses.*

Sixty species and varieties of grasses have been under trial. Most of them occupied plots containing one square rod. About one-half of these grasses were sown in the spring of 1896. Among those so sown the following varieties winter-killed: English rye grass, Italian rye grass, crested dog's-tail and meadow fescue. Among comparatively little-cultivated varieties which appear promising may be mentioned the following: tall oat grass, tall fescue, red fescue, fowl meadow, Canada blue-grass, water-spear grass and wood-meadow grass.

The yield of the dry matter in the hay and rowen (where any was secured) of those varieties sown in the spring of 1896 during the past season, with date of cutting of both the first and the second crops, is shown in the following table. The area in each variety was one square rod.

KINDS.	Date of cutting Hay.	Dry Matter in Hay (Pounds).	Date of cutting Rowen.	Dry Matter in Rowen (Pounds).
Timothy (*Phleum pratensis*), .	July 1,	19.36	Sept. 11,	6.44
Awnless Broom (*Bromus inermis*),	June 25,	14.71	Sept. 11,	6.44
Yellow Oat (*Avena flavescens*), .	July 1,	–	Sept. 11,	4.41
Sweet Vernal (*Anthox anthum odoratum*).	June 4,	2.98	Sept. 11,	4.41
Meadow Foxtail (*Alopecurus pratensis*).	May 17,	5.70	June 25,	7.87
Red-top (*Agrostis vulgaris*),. .	July 6,	31.12	Sept. 11,	8.44
Rhode Island Bent (*Agrostis Canina*).	July 6,	30.81	Sept. 11,	6.41
Fall Oat (*Arrhenatheum avenaceum*).	June 25,	22.85	Sept. 11,	11.86
Glyceria fluitans, ...	July 1,	–	Sept. 11,	–
Meadow soft (*Holcus lanatus*), .	June 25,	10.25	Sept. 11,	6.42
Slender Fescue (*Festuca tennuifolia*).	June 15,	21.43	–	–
Meadow Fescue (*Festuca pratensis*).	Sept. 11,	4.36	–	–
Sheep's Fescue (*Festuca ovina*), .	June 15,	27.85	Sept. 11,	6.61
Tall Fescue (*Festuca elatior*), .	June 25,	27.20	Sept. 11,	17.81
Hard Fescue (*Festuca durinscula*),	June 15,	27.42	Sept. 11,	–
Orchard (*Dactylis glomerata*), .	June 15,	16.41	Sept. 11,	11.96
Red Fescue (*Festuca rubra*), .	June 25,	27.47	Sept. 11,	–
Fowl Meadow (*Poa serotina*), .	July 6,	43.00	Sept. 11,	14.27
Rough-stalked Meadow (*Poa trivialis*).	July 1,	9.87	Sept. 11,	–
Kentucky Blue (*Poa pratensis*), .	June 15,	14.73	Sept. 11,	18.93
Canada Blue (*Poa compressa*), .	July 10,	43.68	Sept. 11,	6.17
Water Spear (*Poa aquatica*), .	July 1,	31.97	Sept. 11,	8.04
Canary Reed (*Phalaris arundinaria*).	June 25,	23.18	Sept. 11,	21.09
Wood Meadow (*Poa nemoralis*), .	July 1,	31.07	Sept. 11,	12.88
Creeping Rent (*Agrostis stolonifera*).	July 6,	15.27	Sept. 11,	–

4. *Millets.*

Twenty-one varieties of millet, occupying one square rod each, were grown for purposes of comparison on medium loam, manured at the rate of 600 pounds of ground bone and 200 pounds of muriate of potash per acre. These were of three species, *Panicum crus galli*, *P. miliaceum* and *P. italicum*. The varieties grown, with particulars concerning amount of seed sown, date of heading, height of plants, and the weight per plot and acre of hay produced, are shown in the table below: —

KINDS.	Ounces Seed Sown.	Date of Heading.	Date When Cut.	Height of Plants (Feet).	Weight, Air Dry, Square Rod (Pounds).	Weight per Acre (Pounds).
Panicum crus galli.						
Japanese barn-yard, . . .	1	Aug. 2,	Aug. 17,	6	65	10,400
Japanese barn-yard, loose headed.	1	Aug. 2,	Aug. 17,	6	63	10,080
Panicum miliaceum.						
Common broom corn, . .	3	July 19,	Aug. 2,	4	51	8,160
Japanese broom corn, red seed,	3	Aug. 2,	Aug. 21,	4 -6	83	13,280
Japanese broom corn, white seed.	5	Aug. 10,	Aug. 29,	5½-6	92	14,720
California, ...	4	July 19,	Aug. 2,	4	62	9,920
Chinese, ...	4	July 23,	Aug. 5,	4	69	11,040
French, ...	4	July 23,	Aug. 5,	4	66	10,560
White French, ...	4	July 19,	Aug. 2,	3½-4	65	10,400
Red French, ...	4	July 19,	Aug. 2,	-	65	10,400
Hog, ...	4	July 19,	Aug. 2,	3 -3½	63	10,080
Panicum italicum.						
Canary bird seed, . . .	4	Aug. 7,	Aug. 2,	-	40	6,400
Dakota, ...	4	July 23,	Aug. 12,	3½-4	60	9,600
Early Harvest, ...	4	July 19,	Aug. 2,	3 -3½	57½	9,340
Golden, ...	3	Aug. 21,	Sept. 4,	5	100	16,000
Golden Wonder, . . .	4	Aug. 10,	Sept. 4,	5	95	15,200
Japanese Glutenous Hokkaido,	3	Aug. 12,	Aug. 26,	4½	63	10,080
Japanese Glutenous Mukodamashi.	3	-	Sept. 15,	2 -4	100	16,000
Japanese common Millet, .	3	Aug. 12,	Aug. 26,	4¾	88	14,080
New Siberian, ...	4	July 28,	Aug. 12,	3 -4	55	8,800

The differences in yield are large, but the scale upon which the varieties were grown is small, — too small, in my judgment, to justify sweeping conclusions as to the relative merits of the several sorts.

The "Dakota" closely resembles the "Early Harvest;" the "loose-headed" variety of the "barn-yard" millet is much less leafy and less valuable than the common form. The so-called "Golden Wonder" cultivated appeared to be like the "Golden." The "Japanese Glutenous," from "*Mukodamashi*," is very late, and does not mature with us. The variety of glutenous millet from *Hokkaido* appears to be a valuable sort. Moisture tests which are being made will very likely change the relative position of some varieties.

5. *Japanese Millets for Seed.*

A small area of each of our three leading varieties of Japanese millets was grown for seed. The soil was fertilized for each variety at the following rate per acre, the fertilizer being sown broadcast and harrowed in : —

Manure, ...	4 cords.
Nitrate of soda, ...	125 pounds.
Dried blood, ...	100 "
Tankage, ...	200 "
Superphosphate, ...	250 "
Muriate of potash, ...	200 "

The season was not very favorable for these crops, and they were somewhat injured on several occasions by the washing of the soil, due to excessive rain-fall.

Barn-yard Variety (*Panicum crus galli*). — The area sown to this variety was .633 acres. The seed was sown May 27, in drills, and was cultivated and hand-weeded. It yielded 1,370 pounds of seed and 4,360 pounds of straw, which is at the rate of 40 bushels of seed and 3 tons 888 pounds of straw per acre.

Japanese Broom-corn Millet (*Panicum miliaceum*). — The area of this variety was .248 acres. It was planted and cultivated like the preceding variety. The yield was 535 pounds of seed and 1,620 pounds of straw, which is at the rate of 40 bushels of seed and 3 tons 532 pounds of straw per acre.

Japanese Millet (*Panicum italicum*). — The area of this variety was .138 acres. It was planted and managed in all respects like the preceding varieties. The yield was 305 pounds of seed and 519 pounds of straw, which is at the rate of 41 bushels of seed and 1 ton 1,761 pounds of straw per acre.

6. *Soya Beans.*

A small area of each of the three leading varieties of Japanese soya beans was cultivated for seed. The yield was at the following rates per acre: early white, 18.7 bushels; medium black, 16 bushels; medium green, 34.5 bushels. The last-named variety thus once more demonstrates its great superiority as a crop-producer over either of the other sorts under trial.

7. *Clovers.*

Tests were begun in 1895 for the purpose of comparing four of our prominent clovers, viz., medium red, mammoth, alsike and crimson. The result of the first year's test will be found in our ninth annual report (pages 27 to 29). As stated in that report, our results indicate that the crimson will not prove valuable as a fodder crop in this locality.

Medium Red Clover. — The crop of this variety compared very favorably with that of the mammoth clover in the season of 1896, but during the winter of 1896 and 97 the plants of this variety were nearly all killed. The plots were accordingly ploughed and sown with oats and vetch.

Mammoth Clover. — This variety was somewhat injured by the winter, but was allowed to stand. Bad weather prevented its being harvested at the proper time, and it was much damaged before it could be secured. It yielded at the rate of about 1½ tons per acre at the first cutting. The second growth was much mixed with weeds. It was cut and weighed green, yielding at the rate of about 2,800 pounds per acre.

Alsike Clover. — This variety, like the preceding, was much injured by rain. It, like the mammoth, was found to have suffered much during the winter. The crop cut was much mixed with weeds, yielding at the rate of 2¼ tons per acre for the first cutting. The second growth was mostly weeds, and was weighed green, amounting to about 5 tons per acre.

Conclusion. — The mammoth clover under the conditions of our experiment has shown greater vitality and productive capacity than either of the other sorts. It is worthy more extensive cultivation.

Sulphate v. Muriate of Potash for Clovers. — As stated in our ninth annual report, there were two plots of each of the varieties of clover under comparison, one fertilized with muriate of potash, the other with sulphate of potash. The results in 1896 showed no material difference in yields which could certainly be ascribed to the nature of the potash salts used. The same is true this year.

The sulphate plots, both of the mammoth and the alsike clovers, yielded most at the first cutting; the muriate plots, in both cases, yielded most at the second cutting; but, as stated, the crops secured at the second cutting were largely mixed with weeds. The results, therefore, must be regarded as without especial significance.

8. Sweet Clover (Melilotus alba).

This crop occupied two plots of two-fifteenths of an acre each, in Field B. The same crop was grown upon these plots in 1896, and the results are fully discussed in our ninth annual report. The growth during that season was for the most part small and unsatisfactory, owing apparently to the fact that the appropriate nodular bacteria were not present in sufficient numbers to enable the crop to make use of free atmospheric nitrogen. A few of the plants in 1896 were found to have abundant nodules upon their roots. These showed a deep-green color and made a vigorous growth. It was judged that, if the land should be thoroughly worked in various directions, the nodular bacteria would be scattered throughout the soil, and that the second crop upon the same land would be better than the first. The soil was accordingly thoroughly prepared, and the seed for the crop of this year sown at the rate of 10 pounds per acre on July 30, 1896.

The growth was very much superior to that of the previous year, and upon examination in the early part of the season it was found that the roots of about one-half the plants were abundantly supplied with nodules. These plants were making a vigorous growth, and had a deep-green color, indicative of an abundant supply of nitrogen. They were at this time evidently able to draw upon the atmosphere for this element. Later the other plants in the field seemed also to gain this ability.

On July 8 the crop averaged 6 feet in height. A portion was cut and fed to the cows kept in the department of foods and feeding. This portion yielded at the rate of about 12½ tons per acre. Dr. Lindsey reports that the cows ate it readily and appeared to be fond of it. It was, however, rather coarse for feeding when allowed to stand until the latter part of July. If to be fed, the crop should be cut early. In average seasons it would be at its best condition during the first half of the month of July. It is not, however, as a fodder crop that I am inclined to recommend a trial of sweet clover, but rather as a crop for green manuring. I believe it may serve here a similar purpose to that served by crimson clover in localities where it is hardy.

Miscellaneous Crops.

Alfalfa. — One-quarter of an acre of light soil was sown on April 17 with alfalfa. The fertilizer applied to the quarter acre was as follows: fine-ground bone, 100 pounds; nitrate of soda, 50 pounds; phosphatic slag, 50 pounds; muriate of potash, 50 pounds. One-half the seed used was treated with nitragin. All the seed germinated quickly, no difference being noticed between the treated and the untreated. The small plants were, however, injured by the heavy rains, and up to date the crop has made but a feeble growth.

Saccaline. — Our trial of this crop has been carried out upon two small plots, the one having a heavy, moist soil, the other a light, drier soil. One-year-old plants were set in the spring of 1896. The growth during that season was feeble. In August of that year each plot was given a good dressing of manure. In the spring of 1897 it was found that a considerable number of the plants had been winter-killed. On the heavy soil 36 out of 408, and on the lighter soil 71 out of 129, were dead; of 451 plants left in a nursery, 258 were dead. Plants which lived through the winter were well started by April 20, but the new growth was killed by a frost. On July 16 the growth, which ranged from 1 to 7 feet in height, the average being about 3 feet, was cut. The plants were large and woody. The yield on the heavy soil, 408 plants, was 295 pounds; on the lighter soil, 129 plants, 132 pounds. The leaves only were eaten by cows, — horses would not eat it at all. A second crop was not cut, but on October 1, when the plants were killed by frost, the second growth averaged about 18 inches in height. As a result of our trial of this crop, I am convinced that it is without value as a fodder crop for us.

Crimson Clover. — A further trial of this crop has been made upon a rather light soil. The seed was sown July 3 with equal parts of winter rye. Nitragin, not received in season to apply with the seed, was mixed with water, according to directions, and applied to the clover August 31, the plants then standing about 2 inches high. The crop was a complete failure, every plant being winter-killed.

Winter Vetch. — A small plot of this crop has been grown upon a light soil. It was sown August 20, equal parts of vetch and rye. This vetch proved perfectly hardy and grew vigorously, reaching a greater height than the rye. This vetch will prove valuable as a green fodder when sown with winter rye.

Besides the above, we have cultivated a few rows each of a large variety of fodder plants, some 39 in number. In this variety are included a large number that have been mentioned in previous reports, and they do not require further notice at this time.

Among those cultivated for the first time this year are the *Idaho field or coffee pea* (*Cicer arietinum*). This appears to be the same as the gram or chick pea, which we have had under cultivation for two years. The growth is too small to make it valuable for a fodder crop.

Another new fodder crop for this year was the *Brazilian stooling flour corn.* The plants made a vigorous growth, but are judged to be too coarse and woody to prove of much value for fodder.

Black chaff or African millet is another crop under trial this year for the first time. It appears to be the same as Kaffir corn, and, as reported last year, our experience leads us to regard this fodder crop as inferior to maize for our climate.

A Reputed Method for Destroying Stumps.

A correspondent in one of our agricultural papers during the summer of 1895 reported that he had found it possible to destroy stumps in the following manner: —

A hole one or two inches in diameter according to the size of the tree, and eighteen inches deep, is to be bored in the stump. Into this put from one and one-half to two ounces of saltpetre, fill with water and plug tightly. Six months later, put into the same hole about one gill of kerosene oil, and set fire to it. The correspondent stated: "The stump will smoulder away without blazing, even down to every part of the roots, leaving nothing but ashes."

On Nov. 4, 1895, fifty stumps of trees cut in 1894, including the following varieties, maple, hickory, hemlock, white pine, yellow birch and elm, were bored according to directions. On December 11 saltpetre and water were put into the holes, according to directions, and the holes plugged. During July, 1896, the plugs were removed, the holes were filled with kerosene, and an attempt made to burn the stumps. It was found that not even the oil would burn. A portion of the stumps were left until June, 1897, when another attempt was made to burn them, using a low-test oil, called paraffine gas oil. The stumps are still in the field. The method has been given a thorough trial, but must be regarded as a complete failure.

Poultry Experiments.

Experiments with poultry were carried out during the winter of 1896 and 1897. Our attention was confined to three points: —

1. Effect upon egg-production of the use of condition powders.
2. Comparative value for egg-production of dry-ground animal meal and cut fresh bone.
3. Comparative value for egg-production of cut clover and fresh cabbage.

General Conditions.

In all of these experiments pullets purchased in Plymouth County and sent to us in December were used. A few had laid before we received them, and production was stopped by the move, as is generally the case. Some of the pullets moulted after reception here, which served to reduce the egg yield. Each of the six lots of fowls occupied a house, with roosting and laying room ten by twelve feet, and scratching shed eight by twelve feet in size. Each had the liberty of a large yard, which furnished a little grass after April 15, but in all alike. Each of the feeding trials began January 1 and continued until May 2, — 122 days.

Soft foods were mixed for the morning mash with boiling water the night before using. Sufficient of the materials for a fortnight were mixed dry at one time. Oats were always scattered in the straw in the shed at noon. At night the wheat was fed in the same manner. As a rule, a little cut bone was fed once a week, in place of the noon ration of oats. About twice a week cabbage was hung up in each coop except the one where cut clover was under comparison with this vegetable. Clear water, shells and grit were before the fowls all the time. Occasionally salt was added to the morning mash. At the conclusion of the experiment the dressed fowls were sent to G. M. Austin & Son, Boston, who reported upon the quality of the several lots.

1. *Effect of Condition Powder upon Egg-production.*

This experiment was carried out in most respects in the same manner as last year. Light Brahmas were selected for this test, 20 in the coop receiving condition powders and 19 in the other. The food of the two lots was the same in kind, with the exception that the fowls in House No. 6 received daily condition powder in the morning mash, in accordance with directions furnished with the powder.

The kinds and amounts of food used are shown in the table: —

KINDS.	AMOUNTS (POUNDS).	
	No Condition Powder.	Condition Powder.
Wheat,	209	220
Oats,	150	150
Bran,	27	28
Middlings,	27	28
Animal meal,	27	28
Clover,	27	28
Cabbage,	28	29
Corn meal,	28	29¼
Bones,	9	9

About three pounds of condition powders were used in the experiment.

The weights of the fowls were taken at intervals, and were as follows: —

Average Weights (Pounds).

	No Condition Powder.	Condition Powder.
January 4,	4.868	4.650
February 4,	5.260	4.950
March 9,	5.360	5.343
April 26,	5.310	5.470
May 3 (after fasting twelve hours),	5.160	5.180
Dressed weight,	4.605	4.657

The results and leading details are shown below: —

Condition Powder for Egg-production.

EXPERIMENT JANUARY 1 TO MAY 2.	Number of Hen Days.	Gross Cost of Food.	Cost per Hen Day.	Cost of Food per Egg.	Number of Eggs.	Weight of Eggs.		Weight per Egg (Ounces).
						lbs.	oz.	
No condition powder,	2,318	$6 61	$0 00285	$0 0124	532	65	1½	1.958
Condition powder, .	2,354	6 68	00280	0125	540	67	4	1.993

The nutritive ratio was 1 : 5.16 for the fowls not receiving condition powder; for the others, 1 : 5.14,—practically identical. The total dry matter in food consumed for each egg produced was: without condition powder, 0.8349 pounds; with powder, 0.8688 pounds. Besides the perfect eggs as shown in above table, the fowls receiving no condition powders laid three soft-shelled eggs; the others, one. There were five sitters in the first lot, eleven in the second.

Samples of the eggs were analyzed, and those from the condition-powder fowls were found somewhat richer in dry matter, protein and fat. The eggs were also tested in two families by careful house-keepers. The reports did not agree in all particulars; but one of the two found the eggs from the fowls which had received condition powders superior in flavor of yolk, flavor of white, in beating qualities and in consistency; the eggs from the other fowls better in color and size of yolks. The other reported the condition-powder eggs strong in flavor and the yolks small. This discrepancy is probably to be accounted for from the fact that the number tested was small. Individual as well as class differences would almost certainly be found in the eggs.

The fowls which had received condition powder were reported as dressing rather better than the other lot.

One fowl in the condition-powder house died during the test; there were no losses in the other house.

In conclusion, I have to say that the differences found in this experiment are too small to be considered decisive. On the side of the condition powder we have size of eggs and weight and quality of the dressed fowls; against the powder, we have the food cost per egg, the weight of dry matter in food per egg, and the loss of one fowl. We are warranted simply in the statement that the powder does not appear to have paid for its use.

2. *Cut Bone v. Animal Meal for Egg-production.*

Each of the two houses contained twenty Plymouth Rock pullets in this experiment. The bone and animal meal were each mixed in the morning mash. The foods used are shown below: —

KINDS.	Cut-bone House (Pounds).	Animal-meal House (Pounds).
Wheat,	213	196
Oats,	149	149
Bran,	27	28
Middlings,	27	28
Buffalo gluten,	–	28
Animal meal,	–	28
Clover,	28	27
Cabbages,	26½	29⅛
Chicago gluten,	27	–
Cut bone,	28	–

The nutritive ratios in the two houses were 1 : 5.05 and 1 : 4.45 respectively.

The average weights of the fowls were as follows: —

	Cut-bone House (Pounds).	Animal-meal House (Pounds).
January 4,	4.75	4.89
February 6,	5.10	5.00
March 9,	5.86	5.28
April 27,	5.44	5.15
May 3 (after fasting twelve hours),	5.28	4.88
Dressed weight,	4.83	4.43

The dressed fowls which had received the cut bone were reported slightly better than the other lot. The leading details and results are shown in the following table: —

Cut Bone v. Animal Meal.

Experiment January 1 to May 2.	Number Hen Days.	Gross Cost of Food.	Cost per Hen Day.	Cost of Food per Egg.	Number of Eggs.	Weight of Eggs.		Weight per Egg (Ounces).
						lbs.	oz.	
Cut-bone house, .	2,279	$6 61	$0 0028	$0 0130	508	64	9	2.0034
Animal-meal house, .	2,440	6 24	0025	0097	639	80	15	2.0270

There was, in addition to the eggs as shown by the table, one soft-shelled egg in each house. Two hens in the cut-bone house died during the experiment, from diarrhœa; those in the other house were healthy throughout the experiment.

The dry matter per egg was, where cut bone was fed, 0.877 pounds; on animal meal, 0.69 pounds. The number of sitters was 6 in the cut-bone house, 12 in the other.

A sample of eggs from each house was subjected to analysis. Those produced on the cut bone contained rather more protein but less fat than the other. A test for cooking quality was indecisive; one of the two house-keepers having preferred one lot; the other the opposite lot.

The advantage in this trial is, then, clearly with the animal meal as a food for egg-production. It has given more eggs of a greater average weight and at considerably less cost than the bone; and it is, moreover, a more convenient food to use, as well as safer. The results this year are thus the opposite of those of last year. We have now repeated this experiment four times, with results twice favorable to the bone and twice to the animal meal, but have not before found so decisive a difference as this year. We repeat the experiment again this winter.

3. *Clover Rowen v. Cabbage for Egg-production.*

Plymouth Rock pullets were used in this experiment; but they were later-hatched fowls than those in the experiments already described. There were twenty fowls in each of the two houses, at the beginning. One fowl died in each house during the experiment, from unknown causes. The cut clover was fed in the morning mash. Instead of the clover, a fresh cabbage was kept before the fowls in the other house.

The foods used are shown in the table: —

KIND.	Clover House (Pounds).	Cabbage House (Pounds).
Wheat,	223	212
Oats,	150	149½
Bran,	28	36
Middlings,	28	36
Animal meal,	28	34¾
Clover,	26	–
Cabbage,	–	46¾
Cut bone,	8½	8½
Oat meal,	28	36

The nutritive ratio was practically the same in both houses: viz., in the clover house, 1 : 4.99; in the other, 1 : 4.838.

The average weights of the fowls were as follows: —

DATES.	Clover House (Pounds).	Cabbage House (Pounds).
January 4,	4.560	4.530
February 4,	5.480	4.800
March 8,	5.420	5.350
April 27,	5.470	5.394
May 3 (after twelve hours fasting),	5.289	5.184
Dressed weights,	4.780	4.890

The leading results and details are shown in the table : —

Clover Rowen v. Cabbage for Egg-production.

Experiment January 1 to May 2.	Number of Hen Days.	Gross Cost of Food.	Cost per Hen Day.	Cost of Food per Egg.	Number of Eggs.	Weight of Eggs.		Weight per Egg (Ounces).
						lbs.	oz.	
Clover house, . .	2,356	$7 033	$0 0029	$0 0150	466	59	10	2.0472
Cabbage house, . .	2,423	6 988	0028	0118	588	75	1	1.9880

In addition to these, the fowls in each house laid one soft-shelled egg.

The advantage lies most decidedly with the fowls fed cabbages, in so far as numbers, weight and cost of eggs are concerned. The eggs from the clover house were, however, much superior in cooking and eating quality to those from the other. Both house-keepers reporting are most emphatic in the expression of their preference for the eggs from the fowls fed the clover. One reports : "The eggs from the clover lot are in every way superior." The other says : "They are superior in color, size of yolk and flavor ; " and adds that "they have the finest flavor of any eggs " she ever ate.

Analysis showed the eggs from the fowls fed cabbages to contain higher percentages of dry matter, protein and fat than the others. The superior richness of these eggs apparently renders them strong in flavor.

REPORT OF THE METEOROLOGIST.

JOHN E. OSTRANDER.

The work of the meteorological department during the past year has been in the main a continuation of that of previous years, with such minor changes as, after due consideration, have seemed advisable. The observations for temperature are now all taken in the ground shelter on the campus. The publication of the maximum and minimum temperatures taken in the observatory shelter was discontinued last year, owing to their unreliable character. For the same reason, the observations themselves were discontinued early in April the present year.

The usual bulletins, giving a summary of the records and weather for each month, have been published. An annual summary will be issued as soon as the records for the year are completed.

No material additions have been made to the equipment of the department during the year.

Arrangements have been made to furnish the New England Weather Bureau with the weekly snow reports, as was done last year.

In co-operation with Professor Whitney of the Division of Soils, United States Department of Agriculture, this department installed one of his instruments (kindly loaned by the Department at Washington) for the electrical determination of moisture in the soil. Observations were taken from the latter part of June until early in November. The records, however, are incomplete for the period, owing to breaks in the circuit and other causes which made the instruments fail to work at times. The readings taken were sent weekly to the Department at Washington. The Division of Foods and Feeding of this station made some independent determinations of moisture for standardizing the instrument, and the Division of Botany kept a record of the growth of the crops where the electrodes were buried. Owing to the unusually wet weather during the summer and the incomplete records of the instrument, the results of the experiment were not entirely satisfactory. The department expects to repeat the observations next year under more favorable conditions, and an outfit for that purpose has been ordered.

It is hoped that arrangements may be made to put the electrometer in the tower in working order, so that observations on atmospheric electricity may be undertaken.

REPORT OF THE BOTANISTS.

GEORGE E. STONE, RALPH E. SMITH.

Our work during the past year has been in general a continuation of that of the year preceding. In this, as in other departments of the station, the work falls under two classes: first, examination of material sent in for determination and answering of inquiries; second, investigations of problems connected with plant physiology and pathology.

For the purpose of investigation the greenhouse has been remodelled and enlarged during the past summer, so as to admit of carrying on experiments under more desirable conditions. It is quite essential, in experimenting with plants, that the number employed should be large enough to make it possible to draw deductions from the results with a reasonable degree of certainty that errors arising from individual variation have been counterbalanced. It is also essential that the heat, light and moisture conditions should be equal upon each series of plants under consideration, and that these conditions should compare as closely as possible with the best method of cultivation. In the construction of the experiment house these details have been considered as carefully as possible. The house as now arranged consists of several sections, in which different temperatures can be maintained, for growing tomatoes, cucumbers, lettuce and other important plants subject to destructive diseases. The amount of money invested in the production of greenhouse crops is large and continually increasing, and no small part of our work consists in the study of the various diseases which affect them.

For the last three years we have been investigating methods of controlling the gall-forming nematode worm, which affects cucumbers, tomatoes, English violets, roses, cyclamens and many other greenhouse plants. The results of the investigation are nearly ready for publication, but it seems desirable to first clear up a few remaining points upon the habits of the worm, which are not well known.

Experiments are also being made upon the different methods of pruning tomatoes, and upon the best light conditions for assimilation in greenhouse cucumbers.

With regard to lettuce we are studying the mechanical conditions of the soil as affecting the crop, and the various fungous diseases to which it is subject, more especially the disease known as the "drop."

In addition to these experiments, it may be mentioned that there are incidentally being carried on investigations upon the influence of electrical currents on the growth of plants. Bulletin 43 of this station embodied the most careful and extensive series of experiments ever made upon the subject. They were carried out by Mr. Asa S. Kinney, while a student at the college, and did not necessarily fall under station work. The results obtained by him were of such a promising nature that it has seemed well worth our time to carry the investigation further. It should be stated that any costly method of using electricity as an accelerator of plant development is not to be recommended. If, however, any simple and cheap means of using electric currents can be used, which will give an acceleration in the growth of a crop equal to 30–40 per cent., it might be worthy of consideration by practical agriculturists.

We have in progress a series of experiments with various gaseous substances, with a view to developing a treatment of this sort for combating fungous diseases of greenhouse plants. This method of treatment has been suggested by the extensive application which it has reached in exterminating insects. While we are as yet unable to present any results of great practical value, it is hoped that these experiments may lead to the development of an effective treatment for greenhouse plant diseases by the use of a gaseous substance. The great superiority of such method over that of spraying, which is in many cases inapplicable, needs no exposition. Our experiments thus far have been carried on with two gases, hydrocyanic and formaldehyde. Neither of these appears to answer the purpose. The former, which has been found to be of considerable value as an insecticide, cannot be made effective as a fungicide without using a strength which will prove fatal to the plant. This we have determined by parallel exposures of various fungous spores and plants to the gas, and also by the fact that spores of the carnation rust, taken from plants which had been almost killed by over-exposure, germinated freely. Formaldehyde has a well-marked fungicidal effect, and is much less harmful to plants; but we cannot at present recommend it as a general fungicide, on account of the difficulty of producing it in sufficient strength.

The past year has been an exceedingly abnormal one for vegetation, and as a result this division has had many inquiries concerning plant diseases, different from those of ordinary years. The excessive and long-protracted rains and the lack of sunshine gave rise to a multiplicity of plant diseases such as we have not had for some years. This was the case not only in regard to our various crop plants, but our introduced ornamental species and even our wild plants were unusually affected by fungi. An unusual number of the so-called spot diseases made their appearance, and defoliated to a greater or less extent more than one species of tree. These spot diseases were especially disastrous to the sycamore and butternut, both of which in many instances lost all their foliage; while other trees, such as the chestnut and wild cherry, were more or less affected. The fungi causing these diseases are not new to these trees in this locality, but the abnormal conditions to which all vegetation was subjected proved amply sufficient to accelerate their growth and development.

Whenever the normal conditions surrounding the plant are disturbed, we must expect to find irregularities in its functions; and any serious irregularities in the plant's functions are most likely to manifest themselves by the presence of some insect, fungous or bacterial organism. Abnormal functions, or, in other words, physiological disorders, are in a majority of instances the basis of many plant diseases with which gardeners have to contend; and, since we are liable to observe only the effects of the fungus or bacteria preying upon the plant, we too often think that they are the primary causes of the disease, when, as a matter of fact, they are purely secondary.

This leads us to the subject of spraying as a preventive of plant diseases. From the hap-hazard manner in which it is often resorted to, one would gain the idea that it is intended as a curative rather than as a preventive remedy. This idea is erroneous, inasmuch as spraying is intended as a prevention rather than a cure. This misconception of the proper use of spraying solutions gives rise to the practice of using the Bordeaux mixture as a panacea for every plant disease. Upon this point we wish to state that it must be distinctly borne in mind that spraying under any condition is only a temporary means of preventing certain diseases. The ultimate aim of all progress connected with gardening should be not only to improve the marketable product, but to improve the stock and increase our knowledge pertaining to proper cultivation, so that spraying will be unnecessary. Many experienced gardeners recognize this, and we find experts in almost every line of gardening who have had eminent success in controlling diseases without resorting to the use of fungicides. Some of the most experienced growers of carnations claim that they can control the many diseases which have of late years affected this plant, by simple, judicious methods in the management of the greenhouse.

To expect that spraying is going to save plants that are improperly cared for, or to act as a cure for those already diseased, is absurd. There are many instances where spraying produces beneficial results, and at the present time it appears to be essential, in some instances, to the production of good crops; but there are also many instances where it is entirely useless. This applies especially to the diseases having their origin in improper care or in abnormal conditions surrounding the plant. The condition of the potato crop in Massachusetts during the past summer affords an illustration of how any amount of spraying would not save it from disease, when the soil was soaked with water and the plants in some instances practically submerged for days at a time. Every plant is surrounded by a host of parasitic organisms, which, given the proper conditions, will manifest their distinctive properties. The healthy, vigorous plant is always less susceptible to the attacks of fungi than the weakly, abnormally developed one, — a fact which every practical gardener readily understands. We have seen this illustrated so many times in our work in the greenhouse that it may be well to give an example of it here. Certain species of non-parasitic nematode worms, which are always present in greenhouse soil, although apparently doing no harm as long as the plants are vigorous, will, as soon as the plant becomes weakened or abnormal from any cause, penetrate the tissues and cause rapid decomposition of the same. What is true in regard to nematodes applies also to fungi and bacteria, and, indeed, these various forms of organisms are most frequently to be found together in the decayed tissues of the plant.

Before any attempt is made to spray diseased plants, it is well worth while to find out something about the nature of the disease with which the plants are affected. It is, for example, unwise to spray roses for the black spot or mildew when the roots are half decayed by the action of parasitic gall-forming nematode worms; and for the same reason it would be unwise to treat the spot disease of the English violet, when the roots are covered with hundreds of minute galls, and when the supply of nutriment from the root is greatly interfered with.

On the other hand, spraying the apple, grape, potato and plum is at the present time justifiable and necessary; and there are many diseases common to greenhouse cucumbers and tomatoes which can be largely controlled by spraying, although it must be said here that by judicious management of the various conditions surrounding the plants these diseases can be checked.

The Causes of the Failure of the Potato Crop of 1897.

The disastrous effect upon agricultural crops of the excessive rainfall of the past season has been especially marked upon the potato. The small yield and large amount of rotting of this staple may be easily attributed to this source. In all sections of the State, as well as beyond our borders, the report has been general of a small potato crop and excessive rotting. This rotting has been generally regarded as resulting from the well-known and ordinary "potato rot" fungus, Phytophthora infestans. In fact, however, we have to describe a series and variety of agents, which, under the favorable influence of the excessive rainfall, — an influence unfavorable to the vitality of the plant, — have brought about the diminution and destruction of the crop.

At planting time the ground was extremely wet. The crop, however, started well, and the plants appeared above ground in a promising manner. Continuous rains kept the soil saturated with moisture, and before the plants had reached a height of more than six inches it was noticed in many places — usually the lowest and wettest portions of the field — that many of them were dying. Such plants did not collapse suddenly, but gradually turned yellow and faded away, most of them dying eventually, though here and there one would be seen which maintained a feeble, stunted growth through the season. This was the case not only in this vicinity, but it was also reported from various parts of the State.

Investigation of affected plants showed that the trouble was due to a rotting of the stem of the young plant below ground, which rotting evidently proceeded from the seed potato, which was found in every case to be a putrid mass, while the decay was gradually extending up the young stem. Careful search for the cause of the rotting failed to reveal any particular organism to which it could be ascribed. That it was of bacterial origin seemed quite certain, as the decayed tissue swarmed with organisms of this class, while no fungus which could be considered the cause of the rotting was found. In the cortex and exterior portions of decayed stems several forms of Micrococcus and also other bacteria were found in abundance. In the interior portions a large, motionless bacillus occurred quite abundantly and exclusively, and may have been the primary cause of the rotting. The most probable explanation, however, seems to be that the normal functions of the plant were disturbed and its growth checked by the unusual amount of moisture in the soil. The seed potato, with its supply of reserve food material for the young plant thus left idle in the soil, naturally rotted away, and this rotting communicated itself more or less to the young stem proceeding from the "seed." The plant, not being in a condition of vigorous growth to resist this rotting, gradually succumbed to it, and in most cases died. The few plants, as mentioned above, which continued a feeble growth through the season, accomplished this by throwing out roots above the rotted portion of the stem, and thus prolonged a feeble existence. Such plants produced no tubers, and consequently had no value whatever.

This, then, was the first of the troubles affecting the potato crop in this section. We do not describe or consider it as a specific "disease" of the potato, nor do we deem it necessary to consider any treatment for it. We at first recommended removing affected plants, but doubt now if such a course would have been of any considerable practical value. We are inclined to believe that the trouble was not brought about by any specific or especially destructive organism, but was simply the result of the unusual meteorological conditions of the season, and under such conditions could not be prevented from occurring by any means at our command.

By July 1, most of the plants which had fallen a prey to the above disease were withered away and dead, while those which had escaped had made a fairly good growth and nearly reached maturity in point of size. About July 15 several hot, sunny days came on, following a long very rainy spell. In many potato fields on low ground the plants began to wilt and die down. In a large field at the college, situated on a long slope, the plants at the top were unaffected, but those in a limited area at the bottom of the slope — the wettest part of the field — began to wilt (see plate). Many had already died here from the effects of the first disease. It is a well-known fact that plants often wilt when exposed to strong sunlight after a continued cloudy and wet period, this being due to excessive evaporation or transpiration of water from the leaves. In this case, however, the wilting was too pronounced to be attributed to this simple physiological phenomenon. Investigation showed that the leaves were not "blighted" nor were they affected in any way except the simple wilting, which was evidently caused by some trouble at the root. Plants were then dug in various portions of the affected area, and in all stages of collapse, and their roots examined for the cause of the trouble. It was found that there was no one organism (except possibly bacteria) attacking the plant, but there was a general rotting, resulting from the wet condition of the soil and consequent low vitality of the plant. The features of this rotting varied greatly in different plants, however, and scarcely any two were affected in an exactly similar manner, it being almost impossible to specify a feature of the disease common to all, except the wilting of the tops. In the very wettest part of the affected area the tubers were rotting badly. These rotten tubers were swarming with bacteria, but they were of various kinds, and to no one could be ascribed the beginning of the trouble. Various species of fungi were found in some, but these were moulds and similar forms, and included nothing which by any probability could have caused the rotting. Since fungi were entirely absent in many of the rotten tubers, it is certain that they did not cause the trouble. In many cases the decay seemed to have started where a grub of some kind had eaten into the potato. On somewhat dryer ground, where the plants wilted, the tubers were not rotten. In many cases, however, the stem was found to be decayed just where it joins the root. The young rootlets were also rotting, so that the cortex fell away from the central portion. These symptoms also occurred, and more pronouncedly, in cases where the tubers were rotten. In these decayed stems and roots no one organism could be found as the cause of the rotting. Bacteria (mostly micrococcus) swarmed in all affected parts, and several mould fungi also occurred. Quite noticeable on all affected plants was the occurrence on tubers and even on the base of the stem, of small, white, mealy dots, scattered abundantly over the surface. These were apparently enlarged lenticels, being composed of parenchymal cells breaking out at the surface. It seems probable, or is at least possible, that their production was due to the scarcity of air in the wet soil.

We can only conclude here, as in the other case, that this cannot be called a definite disease, but rather was the result of abnormal and unusual conditions. During the long-continued rain the living functions of the plant were disturbed and its growth checked. Various organisms then came in, and, gaining a foothold, so weakened it that when the sun came out it wilted down and in the worst cases died. Had it been possible to thoroughly cultivate and stir the soil at this time, it is reasonable to suppose that much of the trouble might have been averted; but the extreme wetness made such a course impossible.

This trouble came on after the potatoes had reached a marketable size. We therefore recommended digging them in all affected places, in order to save them from decay. Beyond this there could be no practical treatment suggested.

Early in August, or even sooner, the real potato blight or rot, Phytophthora infestans, began to appear, and developed very extensively during the month, killing the tops of potatoes everywhere, and causing great loss by rotting of the tubers. This disease is too well known to need extended description. Its ravages might probably have been controlled to some extent by thorough spraying throughout the season, but it would have been practically impossible to entirely prevent it in such a summer.

THE "DROP" OF LETTUCE.

The loss represented by this disease frequently amounts to thousands of dollars in a single season in Massachusetts. Almost every lettuce grower has had more or less experience with it, although, as with every other disease, some have been much more affected than others. We have known several instances during the season where extensive growers have lost practically their whole crop, and, as a consequence, have become much discouraged with lettuce growing. Inasmuch as the general characteristics of this disease were given in the ninth annual report, it is not necessary to enter upon any minute description here. Suffice it to say that the disease makes its appearance in the stem, close to the surface of the ground, where the tissue becomes slimy and soft, and eventually the whole stem at this point disintegrates and collapses. This occurs most frequently just as the plants reach maturity.

The fungus causing this disease is well known to all greenhouse men. The "damping fungus" (Botrytis), which causes the drop, often gives rise to disastrous effects on begonia and other cuttings in the propagating pit. The fungus, however, as it appears upon the lettuce, presents some aspects which are different from its appearance upon cuttings, and reaches a more advanced stage of development. Our present knowledge in this direction possesses more of a technical than practical interest, although an understanding of the complete life history of the fungus will, no doubt, lend much aid to its rational treatment.

The natural conditions governing the development of the organism appear to be similar to those of most organisms, — that is, it requires the presence of oxygen. It is well known that almost any object when driven into the ground will undergo disintegration much more rapidly at the surface of the soil, for here the conditions of moisture, etc., are most favorable for the organisms producing disintegration. And so it is with the "drop" fungus; it finds just the conditions at the surface of the soil, under the moist, shady leaves of the mature lettuce plants, for its destructive work.

Our experiments upon the control of this fungus are by no means complete, but it will not be out of place here to offer some suggestions in regard to its general habits and the methods of treatment which may be tried. Probably every grower has the germs of the disease in his lettuce soil to a greater or less extent, but the conditions giving rise to their excessive development are not always present. Some claim that manure is the principal source of infection; yet, on the other hand, while all use manure, all are not troubled in the same degree. As a remedy for the drop, some have resorted to the practice of sanding the surface of the soil or putting on a layer of yellow loam. This is for the purpose of giving a clean, uninfested surface to the soil surrounding the plants. In regard to the effect of this treatment, it may be stated that opinions differ considerably. Whether the method of applying a superficial layer of sand or subsoil to the surface will be of any assistance in keeping the drop in check appears somewhat doubtful, from an experiment made of burying some infested plants to a depth of three or four inches in a pot of yellow loam subsoil. It was found that the fungus made its way to the top in a very few days, as was evident from the mould-like growth of the mycelium upon the surface of the soil and the death by drop of plants which had been set in the pot. Neither can we expect much from the application of chemicals, as any such treatment would interfere with the growth of the plant, and hence become objectionable. Some experiments are now being made with gases, with the idea of killing the organism by fumigation; but this method does not promise much success.

The application of live steam to the soil, and thus sterilizing it, would undoubtedly destroy the germs of the disease. To do this would necessitate laying two-inch tile at a depth of eight inches or a foot below the surface of the soil, and at a distance of one or two feet apart, and driving in steam under pressure and allowing the same to permeate the soil. This method can be employed on a small scale with good results, but the larger area of a lettuce house would render its practical application uncertain. Another method of treatment by steam, which would be far cheaper, would be to sterilize the surface of the soil to a depth of three or four inches or more. This can be done by constructing a pit in the lettuce house and covering the bottom with tile or one and one-half or two inch steam piping. The tile allows the steam to escape very readily; and, in order to get the best effect, they should be laid close together, say one foot, or less. In case steam pipes are used, — and they are probably more effective than tile, — they should be bored with holes every three or four inches, to allow the steam to escape. With an arrangement of this kind, one would be able to sterilize the soil in a few hours. A pit twenty feet long, ten feet wide and eighteen inches deep would hold sufficient soil to cover twelve hundred square feet of surface three inches deep. The time required to heat this earth up to 200° F. would be only a few hours. Of course the pressure of steam available, the closeness of the pipes and the number of outlets for the steam would largely determine the time necessary to heat the earth.

Various methods of treatment for this disease are being tried, to determine how it may be most effectually dealt with. In connection with the method of steam sterilization, which seems by far the most promising, it is especially desirable to ascertain just how deep the soil must be sterilized in order to keep down the fungus.

The Asparagus Rust.

(*Puccinia asparagi.* D. C.)

In the last annual report of this division attention was called to a new disease which had appeared upon the asparagus, and the apprehension expressed that it might come to be a serious matter. That apprehension has been more than justified. The asparagus rust, unknown to the growers of Massachusetts in 1895, slightly prevalent in 1896, has appeared everywhere during the past season, and bids fair to become a most important factor in the growing of this crop.

The disease first appeared in the fall of 1896, both in this State and in several others, but was not generally prevalent at that time, although in some fields it was very abundant. Cutting and burning infested tops was generally recommended and to some extent practiced; but the majority of asparagus growers had not as yet become acquainted with this new danger menacing their crops.

This rust, like the well-known one of the wheat, has three different stages or forms in its development, though in this case they are all developed upon the asparagus plant, while in the other, one form comes upon the barberry bush and the other two upon the wheat and other grains and grasses. When first noticed in 1896, the asparagus rust was in the fall stage, the black rust or *teleuto* stage, the earlier stages not having attracted attention. In 1897 many asparagus fields were found to be affected as early as July 1, and by August the complaint was general throughout the asparagus-growing sections of the State. It was now the red rust, or *uredo* form, which was present, being followed again in the fall by the black form. Apparently almost every field of asparagus in the State was affected before the end of the season. The rust in most cases appeared first on young beds, — which was natural to expect, since the stalks were not being continually cut off as they appeared. In the older beds, from which the stalks were being cut for market, little or no rust appeared until well into July or August, after cutting had been suspended and the tops allowed to develop. In most cases, however, they were soon affected as badly as any. The effect of the rusting was that the tops lost their green color, and turned brown and died prematurely. Mr. George P. Davis of Bedford says in regard to his beds: "The twenty-sixth of July the tops were all turned brown, and looked as though a fire had swept over the field. There was no green to be seen. . . . In handling the tops a fine dust which looked like smoke was quite noticeable." This dust consisted of countless numbers of the spores of the fungus.

The first attempts at checking the rust were made in the fall of 1896, and consisted of cutting and burning affected tops. When the disease appeared so extensively in 1897, many growers cut the tops in August, when they had become badly rusted. It is impossible to say with much certainty what the result of the first cutting (fall of 1896) may have been, inasmuch as comparatively few beds were thus treated or badly affected at that time. A good-sized bed at the college was considerably rusted, and the tops were cut and burned late in the fall. The bed was well cultivated and fertilized, and no rust appeared upon it in 1897 (that is, not enough to be noticeable) until well into the fall, when the black rust stage was quite as abundant as it had been in 1896. Mr. S. T. Davis of Orleans also mentions having observed a small bed, which was cut in the fall of 1896, upon which no rust appeared in 1897. Whether the cutting of the tops or some other factor kept down the rust in these beds, we are not prepared to say. The cutting which was quite extensively practiced in the summer of 1897 seems to have been entirely without effect, as the rust appeared again just as badly on the second growth.

The experience of another season is necessary to demonstrate the actual effect and seriousness of this disease. Its perennial occurrence to the extent of the past season could not fail to have a disastrous effect upon the asparagus-growing industry. It is not the sort of disease which is effectually suppressed by spraying methods, though something of that sort may be developed if it becomes necessary.* It should be remembered, however, that the past season was an unusually favorable one for all fungous diseases, and consequently it may have developed much more extensively than it ordinarily would. If it could be mostly confined to its teleuto or black rust stage, which appears in the fall when the plants have practically completed their growth, it is not probable that any serious injury would result. At all events, the effect of the great prevalence of the rust in 1897 upon the asparagus crop of 1898 will be awaited with great interest by all interested in its cultivation.

THE FIRE BLIGHT.

(*Micrococcus amylovirus.*)

This disease of the pear, quince, apple and other pomaceous trees has been the subject of frequent inquiry during the past season. It ordinarily causes the most damage on the pear and quince, and is one of the most destructive of plant diseases. The trouble appears in the branches, sometimes a whole limb of considerable size, but more often the smaller terminal twigs, being affected. These portions of the tree suddenly wilt and die, the leaves and young fruit turning black and hanging to the branches, producing the characteristic scorched appearance which gives the disease its name. It spreads rapidly about an orchard and increases from year to year, often involving the entire tree and causing its death if left unrestricted.

---

* Recent experiments indicate some amenability of the rust to spraying, although not more than twenty-five per cent. reduction is claimed.

The cause of this trouble was long a matter of speculation, but it is now known to be a species of bacteria which gains access to the tissues of the tree and by its rapid multiplication therein causes great destruction. This disease cannot be reached by spraying, and the only remedy consists in severely cutting back all affected branches, or whole trees if badly affected. All such prunings should then be destroyed by burning. This cutting should be done whenever the disease is observed, but is especially advisable in the fall or late summer, when the trees should be carefully examined, to make sure that no diseased branches or twigs are left to perpetuate the disease over winter. As the disease affects the hawthorne (Cratægus), shad bush (Amelanchier) and mountain ash (Pirus Americana), as well as the cultivated fruits, it may spread from some of these wild trees to the latter, unless care is taken to prevent such contagion. It is not probable, however, that such infection is ordinarily at all extensive.

The Quince Rust.

(*Gymnosporangium clavipes* C. and P.)

The numerous inquiries which we have received during the past season concerning this not uncommon trouble, as well as our own observations, indicate that it has been unusually prevalent and destructive. The disease affects principally the fruit, but also the young wood, causing distortion and malformation in both cases. It is very conspicuous upon the affected quinces in midsummer, both from their distorted shape, and from the numerous white, tubular excrescences appearing upon their surface. These excrescences contain masses of the bright orange-yellow colored spores of the fungus which causes the disease. The fungus has a peculiar course of development. It not only exists in the form seen upon the quince, but has also another form or stage, living upon a different kind of plant and quite different in appearance. This stage of the fungus lives upon the red and white cedar and the juniper, and is one of the forms which produce upon those plants the abnormal growths popularly known as "cedar apples." These cedar apples are peculiar outgrowths upon the twigs of cedars and junipers, reaching their complete development in early spring. They are oftentimes regarded as the proper product of the tree, or as insect galls, — which ideas are equally incorrect. These growths begin to form in midsummer, developing as small excrescences upon the twigs and gradually increasing in size until winter, when they are nearly full grown. An "apple" consists at this stage of an abnormal mass of the cells of the tree, with the filaments of the fungus growing abundantly between them. Remaining thus over winter, the first warm, moist weather of spring starts it into further growth and development. Upon the surface of the affected wood numerous projections appear, of a conical shape, and composed of a yellow, gelatinous substance. These projections are composed of a mass of the fungous filaments and a gelatinous substance which they secrete. In them are produced the spores of this, the *teleuto* stage. These spores are composed of two cells and borne on long stalks. The sudden appearance of these peculiar growths on cedar trees just after a spring rain is often taken for the blossoming of the tree, but is in reality the fructification of the fungus parasitic upon it. The gelatinous appendages of the cedar "apples" soon dry up and wither away after the rain, but not until the teleuto spores contained in them have germinated and produced secondary reproductive bodies called *sporidia*. These are carried away in the air, and proceed to infect, not cedar trees, but quinces or one or two other related plants. Upon the surface of these they germinate and produce filaments which grow into the substance of the young fruit or stems, and by their presence there cause the distortion in shape seen in affected specimens. Upon this host the fungus forms little pustules just beneath the surface, finally breaking out into the air as tubular projections. In these are formed the yellow spores of this stage, called *œcidia.* These spores are unable to infest quinces again, but upon cedar trees begin the development of a new generation of "apples," which will in turn produce teleuto spores the following spring.

Treatment. — It is not often that the damage caused by this disease is of great extent. Sometimes, however, it becomes sufficiently troublesome to make it worth while to attempt to repress it. It is evident that the most vulnerable point of the fungus causing the trouble lies in its inability to reproduce itself continuously upon the quince. The most direct method of treatment, therefore, is to exterminate all white and red cedars and junipers from the vicinity of the orchard, and cut off all affected parts of the fruit trees, or entirely destroy badly affected ones. This, for various reasons, however, may not always be possible or desirable. As to spraying methods, it has been found quite effective to spray with Bordeaux mixture two or three times during the spring, especially during or just after rainy weather, when the spores are being disseminated. It may also be possible sometimes to remove affected twigs of cedar and juniper trees before the spores have been produced.

This same fungus has also been unusually abundant during the past season upon the fruit of various species of Cratægus (hawthorne), accompanied by an equal abundance of the closely related species, Gymnosporangium globosum, upon the leaves. We have also noticed these or related species upon the fruit of the Japanese quince (Cydonia Japonica) and mountain ash (Pirus Americana).

THE BROWN ROT OF STONE FRUITS.

(*Monilia fructigena.* Pers.)

This well-known disease found in the past summer just the conditions suited to its best development, and the peach, plum and cherry crops suffered in consequence. The disease needs no description to those who have ever tried to raise any of the above-mentioned fruits. It appears in the summer, some time after the fruit has set, often just as it comes to maturity, or even earlier in the season, the time of its appearance depending a great deal upon the weather, a warm, rainy period being liable to bring it on at any time. Indeed, it does not always wait for the production of fruit upon which to make its attacks, but often develops upon the blossoms, causing them to abort, and spreading thence into the young twigs upon which they are borne, results in their death. Upon the fruit the rotting is almost always found to some extent at the time of ripening, and, as already mentioned, often occurs earlier in the season when the weather is favorable, i. e., warm and moist. At such times the greater part of the crop is sometimes destroyed. In cherries the chief damage is done upon the ripe fruit. In peaches and plums, which have a longer season of ripening, the young fruit is more frequently affected. Early peaches are considered more susceptible to the disease than the later varieties.

The cause of this disease is a mould-like fungus (a true parasite, nevertheless), which spreads its vegetative filaments through the affected fruit and thus causes its decay. Wet weather brings about the rotting of the fruit by favoring the growth of the fungus, not by its direct effect. Fruit which is affected begins to discolor and soften, and gradually dries up and shrivels into a shrunken mass about the stone. It often remains on the tree for months, especially in the peach. In the early stages of infection the surface becomes covered over with little grayish spots of a powdery, dusty nature. These are clusters of the spores of the fungus, produced in countless numbers on the ends of filaments from the inside of the fruit which have pushed out through the surface. These spores, which serve to reproduce the fungus, are extremely minute in size, so that *en masse* they appear as a fine dust. Being easily carried by the wind, they are spread far and wide, and may thus infect a large district in a few days, under favorable conditions. After becoming dry and hard the affected fruits cease producing spores, but their period of harmfulness is not yet ended. After lying over winter in a dormant state, the fungus in them is again aroused to life by the warm rains of spring, and begins the production of spores which are ready to infect the crop about to be produced.

It has been thought practicable by some to exterminate or at least greatly reduce this disease by the destruction of all affected fruit and thus prevent the fungus from surviving through the winter. The variety of fruits upon which it can exist, however, and the practical hopelessness of accomplishing the destruction of any considerable proportion of it, together with the uncertainty of the fungus being altogether dependent upon the dormant stage found in the dried-up fruit for its existence over winter, make the success of this plan very doubtful. We would not, however, discourage the practice of removing and destroying the affected fruit, especially any remaining upon the trees over winter; for this may result in future decrease of the rotting, especially in isolated orchards or trees.

The usual methods of orchard spraying have been found to keep this disease in check to a considerable extent, though in favorable weather it will often sweep through an orchard, despite all precautions. The spraying should be begun early, and kept up through the season with considerable frequency, especially near the time when the fruit is maturing. For such spraying, Professor Maynard recommends the use of the ammoniacal copper carbonate or a weak solution of copper sulphate. Details in regard to the treatment of this disease may be found in Bulletin 44 of this station.

The Chrysanthemum Rust.

(*Puccinia Tanaceti*, S.)

In the last annual report a rust upon chrysanthemum leaves was described, this being, as far as known, the first published mention of such a disease. The specimens were sent by Mr. G. H. Hastings of Fitchburg, who had experienced heavy loss as the result of the rust. This was the only occurrence of the disease encountered during 1896.

This year it has appeared in many places, both in this and other States, occasioning considerable loss, as it is often very destructive to infected plants. It is not yet generally known, however, among those who cultivate the chrysanthemum, though we fear that it may be by another year. Judging from the history of many similar diseases (asparagus rust, carnation rust, hollyhock rust, etc.), it will not be surprising if a general epidemic of this disease occurs next year. It will be well worth while, therefore, for growers to take precautions for guarding against it as much as possible, especially those whose stock is already infected. Great care should be exercised to get cuttings from vigorous plants, unaffected by the rust; and it will no doubt be profitable in the end to spray them a few times during the summer with the Bordeaux mixture or potassium sulphide, using one ounce of the latter in two gallons of water, or stronger, if the leaves will stand it. Should the rust appear on the young plants, they should certainly be sprayed at once and at frequent intervals thereafter, and the affected plants removed and destroyed. It will be useless to try to save them as they are doomed to destruction, or at best will only attain a weak, sickly, worthless growth. When the plants are placed in the benches for the fall, great care should be taken that no rusty specimen goes in, else it may bring about the ruin of the entire lot. Further than these suggestions little more can be said about the disease until time shall have shown what its seriousness may be and to what extent it can be controlled.

There are several other diseases affecting the leaves of the chrysanthemum, so that some may be in doubt whether their plants are really infested with the rust. It causes discoloration of the leaves, like other less destructive diseases, but may be distinguished from them by its production of small pustules, of a dark-red, powdery substance, on the under side of the leaves, something as in the carnation rust. This red powder consists of the spores of the fungus, which reproduce and disseminate it.

A Disease of the Cultivated Geranium.

During the past summer there appeared upon the leaves of some geranium plants upon the college grounds a disease which appears to be different from anything heretofore described. The plants in question grew in a long border bed, and comprised several different varieties. Along the back edge of the bed, trees and low shrubbery hung over to a considerable extent, so that the plants in that portion were quite shaded, while those in front were exposed more directly to the sun. The disease came on in the latter part of July, during the rainy weather then prevailing. The leaves began to turn yellow in small spots, which gradually increased in size, the leaf tissue dying away at those points; thus the leaves soon became covered with dead spots of considerable size, and finally lost their vitality completely. The plants in the front of the bed were most affected, those in the shaded portion showing little or none of the disease. All varieties, as above mentioned, were equally affected. The plants were sprayed with the Bordeaux mixture, but with no apparent success. The same disease was brought to our notice in Northampton and also in the eastern part of the State.

The trouble appeared to be the result of the attack of some fungus, but investigation of the affected leaves failed to reveal any such organism. Neither was there any evidence of the presence of insects. Numerous bacteria, however, were found in all affected tissue, and appeared to be the cause of the spotting of the leaves. We do not consider this a genuine disease of the geranium, nor do we expect to find it occurring in the future. That the plants were in a condition of low vitality and hindered growth by reason of the excessive moisture, and hence were an easy prey to organisms which ordinarily would be unable to affect them, seems the most probable explanation. The futility of spraying to prevent such a disease becomes apparent when its real nature is revealed.

Some Leaf Blights of Native Trees.

During the past season several different kinds of trees have been so generally affected with certain leaf-attacking fungi as to become almost entirely defoliated before the end of the summer. While of no great economic or practical importance, these attacks have been so marked and their effects so conspicuous that a brief description of the nature of the trouble may be of interest. The following diseases were generally prevalent wherever the host trees occurred, over the considerable portion of New England which we visited during the summer.

A Leaf Blight of the Sycamore or Buttonwood.

(*Glocosporium nervisequum* Fckl. Sacc)

Numerous inquiries reached us during the spring and early summer concerning the very prevalent and destructive blighting of the leaves of the sycamore tree (*Platanus occidentalis*). It is probable that every good-sized tree of this species in the State was attacked by the disease. The younger trees were apparently, for some unexplained reason, less susceptible. The trouble appeared in May, when the trees, which had just leaved out, appeared as if they had been nipped by a frost or scorched by fire. The leaves withered and turned brown, the new twigs were killed and many of the leaves fell to the ground. In this condition the trees lost all beauty, and became unsightly objects. This disease is not entirely new in this State, although it has never been so generally prevalent before. It was first described in Germany in 1848, and has been common in various parts of Europe since then. In this country it has occurred mostly within the last fifteen years. It first appeared in the District of Columbia, Ohio, Kentucky and other parts of the country south of here, but is now widespread.

The cause of this disease is a parasitic fungus, growing in the leaves and young twigs of the tree, and causing their death. Several other fungi are usually found in connection with the disease, and may have something to do in causing it. This disease is a very serious drain upon the vitality of the tree, and often results in its death. Its occurrence early in the season, however, favors the tree, since it has a chance to, and in fact does, produce a new crop of foliage to carry it through the season. This exhausts the tree, however, and if repeated for several seasons is likely to cause its death.

As to a remedy for this disease, there is little to say. Spraying with fungicides is not to be practically considered, on account of the size and small economic importance of the tree. Gathering and burning diseased branches and leaves might lessen the trouble somewhat; but, if the disease continues to prevail, it will probably be best in the end to dispense with the sycamore as an ornamental tree, and plant something else instead.

A Leaf Blight of the Butternut.

(*Glocosporium Juglandis* (Lib.) Mont.)

No fungous disease has been more noticeable throughout the State during the past season than this. It first became apparent in July, when butternut trees were noticed to be losing their foliage. Examination showed that the rapidly falling leaflets were covered with dead and discolored spots, and had lost their vitality. All trees were not affected in the same degree, as some were almost completely defoliated in August, while others were attacked later or lost their leaves more slowly. By October 1, however, it was almost or quite impossible to find a butternut tree which had not lost the greater part of its leaves.

The cause of the trouble is a fungus, which lives in spots in the leaf, killing the tissue at these points and gradually causing the death of the whole leaflet, so that it falls to the ground. The disease spreads rapidly from leaf to leaf and from tree to tree, and many trees are soon defoliated. It is a well-known fungus, but has been unusually abundant this year.

A Leaf Spot of the Chestnut.

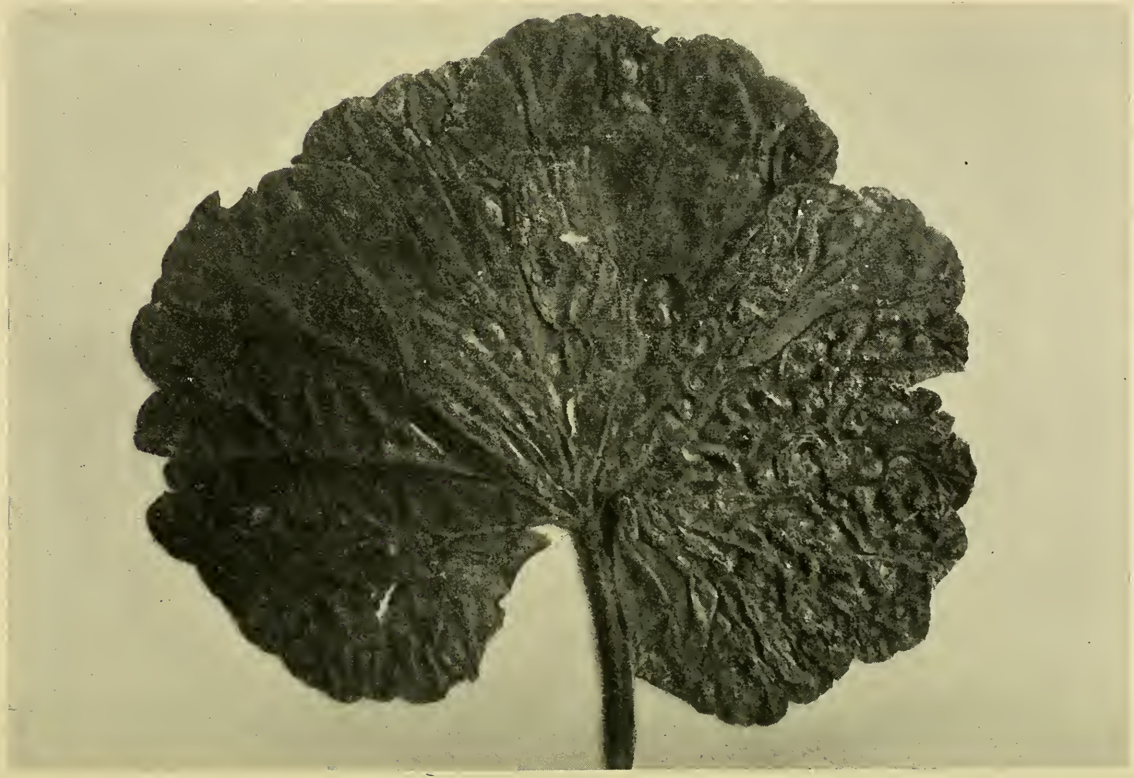
(*Septoria ochroleuca* (B. and C.)

This is another disease, quite similar to those above described, which has been very prevalent this year. It first became noticeable in July, when the ground under chestnut trees was covered with fallen leaves. Upon these leaves the fungus manifested itself very prominently in small, round, dead spots, about one-eighth of an inch in diameter, scattered over the surface more or less abundantly. These spots are the points where the fungus has become established and killed the tissue. The fungus, like all those causing these diseases, reproduces itself by spores, which are produced in minute cavities in the dead area, usually on the under side of the leaf. Almost all the leaves on affected trees become dotted over with the little dead spots, and most of them fall to the ground before their time, thus weakening the tree. The disease is not, however, an especially destructive one, except to the beauty of the tree.

A Leaf Spot of the Wild Black Cherry.

(*Septoria cerasina*, Pk.)

The well-known "shot-hole" fungus, which often causes extensive damage to the plum and cherry, has been exceedingly abundant this year upon the leaves of the wild black cherry (*Prunus serotina*), many trees being almost entirely leafless in August. This fungus attacks the leaves of plums and cherries of several species, producing dead spots upon them, and eventually causing their death. In connection with the wild cherry the disease has little economic importance, except as it may spread from that tree to cultivated species. On this account, the destruction of the wild cherry, so desirable for the repression of the black knot and tent caterpillar, is even more advisable.



BACTERIAL BLIGHT OF GERANIUM

QUINCE.

REPORT OF THE HORTICULTURIST.

SAMUEL T. MAYNARD.

The lines of work in this division the past season have been largely the same as for 1896.

Raspberry Seedlings.

The collection of raspberry seedlings, now three years old, produced a large crop of fruit the past season, and many most promising varieties were found among them. These seedlings were from the hybrid or purple-cap variety *Shaffer*. They produced a great variety of forms, from the black-cap type (*Rubus occidentalis*), the hybrid type of the parent, to some of the most beautiful forms of the red raspberry (*Rubus strigosus*) and to albino forms of both species. Careful records of the hardiness of cane, vigor of growth, time of ripening, productiveness and quality were made during the season, and at this time the plantation is a very handsome one.

Another collection of seedlings from the same source, but one year younger, also shows many interesting forms of growth.

Seedling Currants.

About three hundred seedling currant bushes two years old have made a good growth and show many interesting varieties.

Grape Seedlings.

The collection of seedling grapes, numbering some six hundred varieties, is very interesting. The growth has been very vigorous and healthy, and most of them are in a condition to yield enough fruit next season to determine something of their value. From the appearance of the foliage and the growth of vine we may look for a great variety of types of fruit.

STRAWBERRY SEEDLINGS.

This collection, numbering about four hundred varieties, is in a very fine condition, and some varieties have shown decided merits.

NAMED KINDS OF STRAWBERRIES.

Many new varieties of strawberries of decided merit have been added to the collection. Many of the older varieties of little merit have been discarded, and the plots at this time never looked so well.

STRAWBERRY FIELD.

The field crop is planted on the knoll south of the old farm buildings, and is in a remarkably good condition. This land is of a gravelly nature, but with a retentive subsoil of hardpan, which in an ordinarily moist season may be depended upon to produce a large crop of fruit, but in a very dry time suffers severely. The land slopes in such a manner that either the trench system or the spraying systems of irrigation or sub-irrigation can be employed in case of drought. Two reservoirs on the grounds are available for this purpose, and the three methods may be comparatively tested. A considerable quantity of two and one-half and two inch pipe on hand is available for this work. This need not be of any great expense, while its importance is very great, as no comparative results have ever been obtained that show whether any of the methods can be profitably employed, or which is the most valuable.

VARIETY TESTING.

The value of the comparative tests of varieties of fruits, vegetables, flowers, etc., is often discussed. That it is a legitimate and important part of the work of the stations is shown in the demand made for the publications recording the results of such tests. When we consider the large number of new varieties of fruits, vegetables, etc., offered to the public every year at high prices, with the claim of merits for them far above those of the standard sorts, and which the average grower cannot afford to buy and test, it is certain that the stations can save the people much loss and expense.

In the work of variety testing at this station in past years, the reports show that the new varieties reported as being the most valuable have been those that later were considered most valuable and were most largely grown by the commercial grower, while the varieties reported as having little or no value have been everywhere soon discarded by the growers who tested them. This work would be of much greater value, without doubt, if one or more sub-stations in different parts of the State could be established, where the same varieties could be tested under different conditions of soil and exposure.

The large number of new varieties of all kinds of fruit, vegetables, etc., being introduced every year, and generally with extravagant claims of merit, renders this work of the Experiment Station imperative, and the people should refuse to purchase such varieties until they have the endorsement of the stations of several States. A single season's trial of a variety is of very little value. It requires several years, at least, to prove the value of vegetables or even the more early maturing small fruits, while tree fruits require a much longer period.

Other Experiments.

Among the other experiments now under way may be mentioned the destruction of greenhouse insects by the use of hydrocyanic acid; the testing of the value and keeping qualities of some fifty-five varieties of celery; sub-irrigation in growing lettuce under glass; the use of different kinds of mulch for strawberries; methods of overcoming the asparagus rust; testing varieties of dwarf Lima beans, etc.

Reports will soon be made of the results of the variety tests of fruits, vegetables, etc.; the use of "Laurel Green" as an insecticide and fungicide; of arsenate of lead as an insecticide; and of other work done during the year.

REPORT OF THE CHEMIST.

DIVISION OF FOODS AND FEEDING.

J. B. LINDSEY.
Assistants, E. B. HOLLAND, F. W. MOSSMAN, B. K. JONES, H. H. ROPER.

PART I. — LABORATORY WORK.

Outline of Year's Work.

PART II. — FEEDING EXPERIMENTS AND DAIRY STUDIES.

PART I.

EXTENT OF CHEMICAL WORK.

The work of the chemical laboratory connected with this department has very materially increased during the past year. There have been tested 150 samples of water, 197 samples of milk, 2 samples of oleomargarine, 1 sample of butter, 123 samples of miscellaneous substances. In addition to the above, which were sent to the station for examination, there have been analyzed 260 samples of milk and 388 samples of feed stuffs, in connection with experiments in progress by this and other divisions of the station, making a total of 1,147 substances which have passed through the laboratory within twelve months. There have also been carried on, for the Association of Official Agricultural Chemists, chemical investigations, relative to the methods best adapted for the estimation of starch in agricultural products. This has involved a great amount of chemical work, the extent of which it is impossible to express in mere figures.

CHARACTER OF CHEMICAL WORK.

Water. — The analyses of water have been made by the same methods as heretofore, and with the same end in view, namely, to aid farmers and others in guarding against the danger arising from the use of waters coming from polluted springs and wells. Illness frequently occurs in the family, the cause of which it is often difficult to explain, until an examination of the water reveals its pollution with sink, privy, stable or other drainage. The waters tested show much the same condition as in former years; in round numbers, 15 per cent. could be pronounced excellent, 40 per cent. fair, 25 per cent. suspicious and 20 per cent. dangerous for drinking. Fully 50 per cent., therefore, were considered of a suspicious character. Three samples were found to contain lead, and had been known to have produced lead poisoning. We can only repeat the advice given in former years, in cautioning all who are obliged to depend upon wells and springs for their water supply to take every precaution to prevent any drainage from entering, and to keep the grounds about the well or spring free from all objectionable matter. Lead pipes should never be used to draw water through, especially if the water is free from mineral matter (soft).

Milk. — The most of the milk received at the station has been sent by farmers who ship their milk to Boston contractors. They had probably been notified by the contractors that their milk was below the Massachusetts standard,* and they wished to ascertain its exact quality, and what, if anything, could be done for its improvement. The larger part of this milk was found to contain 12 to 12.5 per cent. of solids and from 3.25 to 3.50 per cent. of fat, and was in all probability the unadulterated product of the cow. The contractor, however, because of the large amount of milk offered, can afford to be particular, and desires only that up to, or above the legal standard. In such cases there is nothing for the farmer to do but to add some grade Jersey or Guernsey cows to his herd. It certainly would be a long step forward, if milk were sold not simply as milk, but with a guarantee of composition. Milk containing 11.5 per cent. solids and 3 per cent. of fat should surely bring less per quart than milk containing 12, 13 or 14 per cent. solids, and 3.25, 4 or 5 per cent. fat.

---

* The Massachusetts standard calls for 13 per cent. solids and 3.70 per cent. fat, excepting during April, May, June, July and August, when but 12 per cent. solids and 3 per cent. fat are required.

Cattle Feeds.—At its session of 1897, the State Legislature passed a law authorizing the inspection of feed stuffs. The work is being carried out by this department, and it is hoped that it will result in keeping out poor and adulterated material, and in keeping the regular articles of as constant a composition as possible. Considerable adulterated cottonseed meal was found on the market during the early spring months. This material consisted of a mixture of hulls and meal, the former ground very fine in order to conceal its identity. The adulterated product contained from 22 to 30 per cent. of protein, while a prime meal should show from 40 to 45 per cent. Farmers were warned through the agricultural and daily papers of the presence of the adulterated article, and cautioned against its purchase. The result of this has been to produce a feeling of uncertainty and to restrict the use of the genuine article. To overcome this, the American Cotton Oil Company have placed a guarantee of composition upon every bag put out by them. It is hoped other manufacturers will follow this example. *Farmers should by all means give the preference to the guaranteed article.*

Other new feed stuffs are those put out by the H. O. Company, under the name of dairy, horse and poultry feeds. The feeding values of these feeds are being investigated. Varieties of oat feeds, being mixtures of oat hulls with more or less corn meal, are found in the market without name or guarantee. Farmers are cautioned against their purchase, for the reason that the price asked is, as a rule, considerably in excess of their feeding value.

Methods for the Determination of Starch.—The work undertaken for the Association of Official Chemists, already alluded to, has been reported to them. While more work will be done along this line, it has been quite clearly demonstrated that the so-called Maercker and Reinke methods for the estimation of starch in agricultural products are faulty, and will give altogether too high results. The only method from which reasonably accurate results may be expected is the diastase or malt method,* and this method has been adopted by the official chemists in place of all others.

PART II.

EXPERIMENTS WITH PIGS.

Two experiments have been completed with pigs, and a third is now near completion. These experiments were designed to study the value of corn meal as compared with hominy and cerealine feeds for pork production, when fed in combination with skim-milk. Both these feeds are quite similar in composition. They consist of the hull, germ and more or less bran and starch removed from white corn, during the preparation of cracked hominy and cerealine flakes for human consumption. Cerealine is much more bulky than the hominy feed. These experiments will be published in detail later. It can be said, however, that pigs have made nearly, and in some cases fully, as good growth on these feeds as on an equal amount of corn meal.

SALT MARSH HAY.

A thorough investigation has been completed concerning the general character and feeding value of salt marsh hay. The results are being published in bulletin form. The practical conclusions, briefly stated, are as follows: —

The several varieties of salt hay have, ton for ton, from 10 to 17 per cent. less feeding value than average English hay. When 10 to 12 pounds of salt hay were fed daily, together with 7 or 8 pounds of grain and a bushel of ensilage, the ration produced within 2 to 5 per cent. as much milk and butter as an equal amount of English hay similarly combined.

---

* Sachsse's method can be used for estimating starch in commercial starch and in potatoes.

Because of the less market value of salt as compared with English hay, rations containing the salt hay, as given above, produced milk and butter from 10 to 20 per cent. less than did rations containing English hay. No objectionable flavor was noticed when the salt hay was fed directly after milking.

It is undoubtedly wise for farmers living near the salt marshes to feed salt hay and sell English hay. For the results in detail, and a fuller discussion, see the bulletin.

Digestion Experiments.

During the past year we have studied the amount of actual nutriment in salt hays, to which reference has already been made, in a number of new by-products and in green crops for soiling. Many of our results, together with practical conclusions therefrom, will soon be ready for publication.

COTTON-SEED FEED AS A HAY SUBSTITUTE FOR MILCH COWS.

J. B. LINDSEY, E. B. HOLLAND AND B. K. JONES.

THE EXPERIMENT CONCISELY DESCRIBED.

What Cotton-seed Feed is. — The seeds of the cotton plant are irregular, egg-shaped in form, and almost hidden by a tuft of white fibre which covers their surface. The meat of the seed is covered with a thick, tough hull of a black color. Machines have been invented to remove this hull, and the meat is subjected to warm pressure for the purpose of removing as much as possible of the oil. The pressed meat or cake is ground, and results in the decorticated, bright yellow cotton-seed meal of commerce. The black hull, covered with the white fibre, was formerly almost entirely used as fuel, and the ashes were sold for fertilizing purposes. Of late many southern farmers, at the recommendation of experiment stations in the south, have been mixing these hulls with the cotton-seed meal and feeding them to beef and dairy cattle, with very good success. Within the last few years this material, under the name of *cotton-seed feed*, has been offered in our Massachusetts markets. The manufacturers claim that the feed consists of 1,600 pounds of hull and 400 pounds of meal, thoroughly mixed by machinery. The price charged has been $13 per ton in car lots, delivered in Massachusetts, which would be equivalent to at least $15 in single tons. The feed, shipped in bags, is quite bulky, and, because of the white fibre covering the hull, looks somewhat like wool waste. Its color is light yellow, due to the admixture of the cotton-seed meal.

THE EXPERIMENTS BRIEFLY STATED.

The experiment station has conducted four experiments with this feed, two with milch cows and two with sheep.

The feed for the first experiment was furnished by the manufacturers. In the second experiment we procured the separate ingredients, and mixed the feed ourselves. Each of the two milk experiments was made with six cows. In the first experiment the feed consisted of a constant grain and ensilage ration, together with a good quality of first-cut hay and cotton-seed feed; in the second experiment there was a constant grain and mangel ration, in addition to the hay and cotton-seed feed. The cotton-seed feed was looked upon as being similar in character to hay, and, in attempting to get at its value, from 12 to 15 pounds were substituted daily for a like quantity of hay. The first experiment lasted twenty-one days and the second twenty-eight days. In case of digestion experiments, in which six single tests were made, some of the sheep received nothing but the cotton-seed feed, and others received half hay and half of the feed. While the cotton-seed feed has not an attractive appearance, the animals in all cases ate their daily rations with no apparent objections.

THE RESULTS.

I. The total average gain of the six cows in live weight during the cotton-seed period was 95 pounds, and during the hay period 166 pounds.

II. The production of milk, milk solids and butter fat was so nearly alike in the average of both experiments as to be within the limits of experimental error.

III. The cost of producing milk and butter with the hay and with the cotton-seed ration varied but very little.

IV. A ton of cotton-seed feed contained about 964 pounds of digestible matter, and a ton of the hay about 1,007 pounds of digestible material.

V. A full description of the experiments, together with all data bearing on the results, will be found further on.

IS COTTON-SEED FEED ECONOMICAL FOR MASSACHUSETTS FARMERS?

There would unquestionably be no advantage for the average farmer to feed this material in place of hay, unless he could sell his hay for a sufficient advance over the cost of the feed to warrant the change. Milkmen in the vicinity of large cities, and others who are obliged to purchase their coarse feed, might find it to their advantage to use some of this material, especially if it could be bought for less than a good quality of hay. It is possible that animals would tire of this feed sooner than of hay. The cows used by the station consumed it continuously for over a month with no seeming objections. The cotton-seed feed must be looked upon from a feeding stand-point in the light of a hay substitute, and not as a grain feed, and only 8 to 10 pounds should be fed each animal daily, in place of a like amount of hay or other coarse fodder. Southern rather than northern farmers can utilize cotton-seed feed to the best advantage.

The Experiments in Detail.

In 1889 Stone [*] records the fact that increasing quantities of cotton-seed hulls and various mixtures of hulls and cotton-seed meal were being fed by the farmers of the south for beef and milk production. Since 1889 a great variety of digestion and beef-producing experiments have been made by the North Carolina station,[†] which have been productive of a large amount of information relative to the physiological and economic value of cotton-seed feed. The Texas experiment station [‡] has made experiments with milch cows to study the economic value of this feed in a variety of fodder rations.

In 1894 Armsby [§] published the results of two experiments with cotton-seed feed. In the first experiment the cows, five in number, were fed as follows: Ration I. consisted daily of 7.95 pounds of wheat bran and 11.69 pounds of cotton-seed feed; while Ration II. contained 3 pounds of cotton-seed meal, 7 pounds of corn meal, 6 pounds of corn fodder and 3.27 pounds of hay. Practically, the corn meal and cotton-seed meal of the second ration were matched against the bran, and cotton-seed meal contained in the cotton-seed feed of the first ration, leaving the corn fodder and hay to be compared with about the same quantity of cotton hulls. The results, as would naturally be expected, were in favor of Ration II. This latter ration contained also 4 pounds more of digestible matter. In the second trial, six cows were each given daily 6 pounds of Buffalo gluten feed and 2 pounds of wheat bran. Ration I. contained in addition 10.6 pounds of cotton-seed feed, and Ration II. 4 pounds of corn meal and 9.7 pounds of clover hay. It is not possible to regard this as a fair comparison, for any one can see at a glance that 4 pounds of corn meal and 9.7 pounds of clover hay (13.7 pounds) must give better results than 10.6 pounds of cotton-seed feed. At least a fairer comparison would have been to have matched the cotton-seed feed against a like quantity of clover hay. Simply because cotton-seed feed consists of a mixture of cotton-seed hulls with cotton-seed meal, it is not at all necessary when making a comparison to put the like amount of cotton-seed meal or other grain into the opposite ration. By so doing, one simply compares cotton-seed hulls with some other fodder or fodder combination. The hulls themselves have an inferior nutritive value; experiments have demonstrated that their nutritive effect is increased by the addition of the cotton-seed meal. In order, therefore, to get at the feeding value of this material, it must be regarded as a single feed stuff, and ought to be compared with other coarse fodders of similar composition. It has been the aim of the experimenter, in the two experiments that follow, to make such a comparison.

---

[*] Tennessee Experiment Station, Vol. II., No. 3, 1889.

[†] Bulletins 80c, 81, 87d, 93, 97, 106, 109, 118.

[‡] Bulletin 33, 1894.

[§] Report Pennsylvania Experiment Station, page 44, 1894.

A. Composition of Cotton-seed Feed.

The first lot of feed, supplied through the kindness of Mr. H. C. Haskell of the Southern Cotton Oil Company of Savannah, Ga., was said to have been mixed in the proportion of 1,600 pounds of hulls to 400 pounds of meal. The lot for the second experiment we prepared ourselves, in the same proportion. The two lots varied very little in moisture, but, for the sake of more exact comparison, the results are presented in dry matter.

	No. 1 (Per Cent.).	No. 2 (Per Cent.).	Theoretical Protein Content of No. 2 (Per Cent.).	Composition of Two Samples of Hay fed in the Two Experiments (Per Cent.).	
				I.	II.
Ash, . . .	3.82	3.51	–	5.94	5.78
Protein, . .	13.02	11.98	13.85	11.07	8.41
Fibre, . . .	39.67	40.69	–	32.00	33.98
Extract matter, .	39.59	40.13	–	47.92	49.15
Fat, . . .	3.90	3.69	–	3.07	2.68

Both Nos. 1 and 2 run rather below the theoretical percentage of protein. This is not surprising, from the fact that it is extremely difficult to get a strictly average sample of this feed. It is impossible to grind the hulls fine, and in spite of all one can do, more or less of the meal will fall through the hulls and not be included in the sample. It will be noted that the cotton-seed feed and the hay resemble each other in chemical composition, excepting that the cotton-seed feed contains somewhat more fibre and less extract matter.

B. Digestibility of Cotton-seed Feed.

Recognizing the valuable information secured by digestion tests, six single trials with sheep were made of the two samples of feed. The sheep were grade Southdown mature wethers. In four cases the cotton-seed feed was fed alone, and in the remaining two the daily ration consisted of one-half hay and one-half cotton-seed feed. In both cases the results agree quite closely, except in case of the fat, which showed a digestibility of 98 per cent. when the cotton-seed feed was fed in connection with hay. This high result it was thought best to exclude from the average. The cotton-seed feed appeared to agree better with the sheep when fed in connection with hay than when fed by itself. In the latter case, at the close of the period the sheep began to show signs of digestion disturbances, which would certainly have become quite pronounced had the feeding been continued much longer. The digestibility of the two different samples of cotton-seed feed was practically the same. The North Carolina station has made a very extended study of the digestibility of hulls and meal fed in different proportions. The Pennsylvania station has also made three single determinations. These results, in addition to our own, are tabulated below: —

Digestion Coefficients.

	Proportions fed.	Number Single Determinations.	Dry Matter (Per Cent.).	Protein (Per Cent.).	Fibre (Per Cent.).	Extract Matter (Per Cent.).	Fat (Per Cent.).
Massachusetts station, ...	4-1	6	56	41	56	59	92
North Carolina station, ...	6-1	2	46	46	40	50	82
North Carolina station, ...	4-1	2	54	54	45	58	85
North Carolina station, ...	3-1 1½-1	9	54	64	47	54	85
Pennsylvania station, ...	5-1	3	43	36	31	54	84
Hay of mixed grasses with ten per cent. protein for comparison.	-	-	58	58	60	59	48

The experiments made by the North Carolina station (4–1) and by the Pennsylvania station were carried out with steers. The only difference between the results obtained by the Massachusetts station and those recorded by the North Carolina station (4–1) consists in the higher percentage of protein and the lower percentage of fibre digested by the steers in the North Carolina experiments. The coefficients for fat digestibility also show some variation, but, the fat percentage being comparatively small, the difference is not of so much account. The coefficients obtained by Armsby are lower than would be expected. The coefficients of digestibility for an extra quality of hay are not very noticeably higher — excepting the protein — than those for the cotton-seed feed.

According to the average coefficients of digestibility, a ton of the hay and a ton of the cotton-seed feed fed in the milk experiments would contain the following amounts of digestible organic nutrients : —

One ton hay, ...	1,007.3
One ton cotton-seed feed, ...	964.4

One would therefore suppose that a ton of cotton-seed feed would have nearly the same feeding value as a like quantity of hay. There might be one exception to the above statement, in that it is possible that rather more energy would be required to digest the cotton-seed feed than the hay.

C. MILK EXPERIMENTS WITH COTTON-SEED FEED.

Experiment I.

This experiment was conducted during April and May, 1896. The animals, six in number, were evenly divided into two lots. In order to counteract the natural milk shrinkage, three of the animals in the first half of the experiment were fed the cotton-seed feed ration, while the other three were having the hay ration. In the second half this order was reversed. Each half of the experiment lasted twenty-one days, and from seven to ten days were allowed between the halves.

History of the Cows.

NAME.	Breed.	Age (Years).	Last Calf dropped.	Number of Days with Calf.	Milk Yield at Beginning of Experiment (Pounds).
Ada, . .	Grade Ayrshire,	7	Oct. 1	106	19
Red Spot, .	Grade Durham, .	6	Sept. –	90	21
Bessie, .	Grade Ayrshire,	7	Sept. 10	69	25
Beauty, .	Grade Jersey, .	5	Sept. 15	96	20
Red, . .	Grade Durham, .	7	Oct. 8	141	20
Spot, . .	Grade Durham, .	7	Oct. 8	141	20

Five of the above cows had been in two previous experiments since October, 1895.

Dates of the Experiment.

	Cotton-seed Ration.	Hay Ration.
April 8 through April 28, . . .	Cows 3, 4, 5	Cows 1, 2, 6
May 11 through May 31, . . .	Cows 1, 2, 6	Cows 3, 4, 5

Rations consumed Daily (Pounds).

PERIOD.	Name.	Hay.	Cotton-seed Feed.	Wheat Bran.	Peoria Gluten Feed.	Linseed Meal.	Millet and Soy Bean Ensilage.
Cotton-seed feed.	Ada, . .	–	10	2	3	1	15
	Red Spot, .	–	13	3	2	2	20
	Bessie, . .	–	15	3	2	2	20
	Beauty, . .	–	15	3	2	2	20
	Red, . . .	–	15	3	2	2	20
	Spot, . .	–	13	3	2	2	20
Hay.	Ada, . .	10	–	2	3	1	15
	Red Spot, .	13	–	3	2	2	20
	Bessie, . .	15	–	3	2	2	20
	Beauty, . .	15	–	3	2	2	20
	Red, . . .	14.2	–	3	2	2	20
	Spot, . .	13	–	3	2	2	20
Average cotton-seed feed.		–	13.5	2.83	2.17	1.83	19.17
Average hay, . .		13.47	–	2.83	2.17	1.83	19.17

Although but three of the six cows received the same ration at the same time, each animal received during the experiment the two different rations for exactly the same length of time. It will be observed that the only difference between the rations consists in the substitution of the cotton-seed feed for the hay, and *vice versa*. The entire rations were eaten clean, excepting a small amount of hay refused by Red, which was preserved, analyzed and deducted from the total fed. The feeds were weighed out daily and given in two portions. Water was before the animals constantly. The cows were carded daily, and allowed the run of a yard in pleasant weather.

Digestible Nutrients in Daily Rations (Pounds).

PERIOD.	Name.	Total Dry Matter.	DIGESTIBLE.				Nutritive Ratio.
			Protein.	Carbohydrates.	Fat.	Total.	
Cotton-seed feed	Ada,	17.36	1.77	8.30	.67	10.74	1:5.63
	Red Spot,	21.88	2.23	10.10	.82	13.15	1:5.45
	Bessie,	23.42	2.31	10.82	.86	13.99	1:5.61
	Beauty,	23.42	2.31	10.82	.86	13.99	1:5.61
	Red,	23.42	2.31	10.82	.86	13.99	1:5.61
	Spot,	21.88	2.23	10.10	.82	13.15	1:5.45
Hay	Ada,	17.30	1.92	8.74	.50	11.16	1:5.20
	Red Spot,	21.81	2.42	10.70	.59	13.71	1:5.03
	Bessie,	23.90	2.57	11.05	.64	14.26	1:4.92
	Beauty,	23.90	2.57	11.05	.64	14.26	1:4.92
	Red,	23.19	2.53	10.72	.63	13.88	1:4.86
	Spot,	21.81	2.42	10.70	.59	13.71	1:5.03
Average cotton-seed feed.		21.89	2.19	10.16	.82	13.17	1:5.56
Average hay,		21.99	2.41	10.49	.60	13.50	1:4.99

The coefficients of digestibility for the cotton-seed feed and for the hay used in calculating the above digestible nutrients were those obtained in our experiments with sheep. Average coefficients were used for the grain feeds. The above results show but little variation in the digestible amounts of the several groups contained in the two rations.

Weight of Animals at Beginning and End of Experiment (Pounds).

		Ada.	Red Spot.	Bessie.	Beauty.	Red.	Spot.	Total Herd Gain.
Cotton-seed period,	Beginning,	771	891	795	937	1010	957	10
	End,	771	885	792	926	1025	977	
Hay period,	Beginning,	775	892	851	1000	1070	965	40
	End,	775	902	855	1012	1082	977	

Two weights were taken of each animal at the beginning and two at the end of the experiment. No marked variations were noted due to the influence of either ration.

Yield of Milk and Butter.

PERIOD.	Cows.	Total Yield of Milk (Pounds).	Daily Yield of Milk (Pounds).	Daily Yield of Milk (Quarts).	Total Milk Solids (Pounds).	Total Butter Fat (Pounds).	Total Butter (Pounds).	Daily Yield of Butter (Pounds).
Cotton-seed Feed.	Ada,	395.45	18.83	8.76	54.60	18.53	22.75	1.08
	Red Spot,	439.12	20.91	9.72	62.55	22.39	26.70	1.27
	Bessie,	542.11	25.71	11.98	73.50	26.67	31.11	1.48
	Beauty,	444.00	21.14	9.82	56.99	24.99	29.15	1.39
	Red,	416.62	19.82	9.22	55.95	21.00	24.50	1.17
	Spot,	337.25	16.06	7.47	50.32	18.27	21.51	1.01
Hay.	Ada,	402.71	19.18	8.92	54.60	18.90	21.70	1.03
	Red Spot,	455.75	21.64	10.16	64.05	21.29	24.54	1.11
	Bessie,	526.88	25.09	11.67	70.35	23.51	27.75	1.32
	Beauty,	399.89	19.04	8.86	58.17	20.35	23.74	1.13
	Red,	275.50	13.12	6.43	36.22	12.54	14.98	.71
	Spot,	419.50	19.98	9.29	51.58	22.11	25.80	1.23
Total cotton-seed feed,		2,574.55	122.47	56.96	366.37	131.85	155.55	7.40
Total hay,		2,485.21	118.25	55.33	346.92	119.00	138.54	6.60
Percentage increase cotton-seed feed over hay.		3.6—	-	-	5.44—	10.76—	-	-

The cotton-seed feed ration gave a slightly larger amount of milk than the hay ration. A 5.4 percentage increase in the amount of total solids is also noted, while fully ten per cent. more butter fat was produced by the cotton-seed ration. This latter result could hardly have been expected. Should cotton-seed feed exert a favorable influence in increasing the relative amount of butter fat in the milk, other experiments would show similar results, which we shall presently show has not been the case. A part of the decrease in the amount of milk, solids and fat produced by the hay ration can be accounted for in the sudden shrinkage of Cow V. (Red) in the second (hay) period. This cow was a grade Durham, and at the beginning of her second period was about 105 days from calving time. She began then to dry off rapidly, showing a shrinkage of 34 per cent. in yield of milk from that produced in the previous period, while other animals shrank only from 5, to in one case 20 per cent. Had Red shrank only 20 per cent., the total decrease in milk yield in the hay period would have been but a trifle over 1 per cent. The results of this experiment make rather more of a favorable showing for the cotton-seed feed than one would naturally expect, judging from its composition and digestibility. Before, therefore, drawing positive conclusions, the reader is referred to the results of a second experiment, described further on.

Dry and Digestible Matter required to produce Milk and Butter (Per Cent.).

DRY MATTER REQUIRED TO PRODUCE —	Cotton-seed Period.	Hay Period.	Digestible Matter required to produce —	Cotton-seed Period.	Hay Period.
100 pounds milk, . .	107.10	111.56	100 pounds milk, .	64.40	68.49
1 pound milk solids, .	7.52	7.98	1 pound milk solids, .	4.52	4.90
1 pound milk fat, . .	20.69	23.27	1 pound milk fat, .	12.44	14.28
1 pound butter, . .	17.75	19.99	1 pound butter, . .	10.68	12.27

Market Cost of Feed Stuffs.

Wheat bran, ...	$15 00 per ton.
Peoria gluten feed, ...	15 00 "
Linseed meal, ...	20 00 "
Millet and soya bean ensilage, . .	3 50 "
Hay, ...	15 00 "
Cotton-seed feed, ...	15 00 "

With the above figures as a basis, we obtain the following figures for the cost of feed required to produce milk and butter: —

	COWS.	Daily Feed (Cents).	100 Pounds Milk (Cents).	Quart of Milk (Cents).	Pound Butter Fat (Cents).	Pound Butter (Cents).
Cotton-seed period.	Ada, . . .	14.87	79.00	1.69	15.99	13.77
	Red Spot, . .	19.00	90.90	1.95	17.43	15.00
	Bessie, . . .	20.50	79.70	1.71	16.14	13.85
	Beauty, . . .	20.50	97.00	2.08	17.23	14.03
	Red, . . .	20.50	103.40	2.22	20.50	17.52
	Spot, . . .	19.00	118.20	2.54	21.84	18.81
Hay period.	Ada, . . .	14.87	77.50	1.67	16.71	14.43
	Red Spot, . .	19.00	87.00	1.87	18.81	16.10
	Bessie, . . .	20.50	81.70	1.76	18.14	15.53
	Beauty, . . .	20.50	107.60	2.31	21.13	18.14
	Red, . . .	19.90	151.70	3.09	32.62	28.03
	Spot, . . .	19.00	95.00	2.05	18.09	15.45
Average cotton-seed feed period.		19.06	94.70	2.03	18.19	15.49
Average hay period, .		18.96	100.10	2.12	20.92	17.94

The two rations costing the same, the cost of producing milk and butter was rather favorable to the cotton-seed feed ration.

Experiment II. (1896).

In view of the results obtained in the first experiment, it was thought advisable to conduct a second under practically the same conditions. The six cows were all approximately fresh in milk. The experiment was carried out in exactly the same way as the preceding one.

History of Cows.

NAME.	Breed.	Age (Years).	Last Calf Dropped.
Mary,	Grade Jersey,	9	July 1.
Jennie,	Grade Guernsey,	6	September.
Nora,	Grade Jersey,	10	August 23.
Beauty,	Grade Jersey,	6	September 15.
Red,	Grade Durham,	8	August 20.
Spot,	Grade Durham,	8	August 17.

The cows were farrow at the beginning of the experiment, and all were served during the progress of the trial.

Dates of the Experiment.

	Cotton-seed Period.	Hay Period.
October 6 through November 3,	Cows 1, 2, 5.	Cows 3, 4, 6.
November 17 through December 15,	Cows 3, 4, 6.	Cows 1, 2, 5.

Rations eaten Per Day (Pounds).

	NAME.	Hay.	Cotton-seed Feed.	Mangolds.	Wheat Bran.	Chicago Gluten Meal.
Cotton-seed period.	Mary,	2	15	15	5	3
	Jennie,	3	12	15	5	3
	Nora,	–	15	15	5	3
	Beauty,	5	15	15	5	3
	Red,	3	15	15	5	3
	Spot,	3	14.46	15	5	3

Rations eaten Per Day (Pounds) — Concluded.

	NAME.	Hay.	Cotton-seed Feed.	Mangolds.	Wheat Bran.	Chicago Gluten Meal.
Hay period.	Mary, . . .	17	–	15	5	3
	Jennie, . . .	15	–	15	5	3
	Nora, . . .	15	–	15	5	3
	Beauty, . . .	20	–	15	5	3
	Red, . . .	18	–	15	5	3
	Spot, . . .	18	–	15	5	3
	Average cotton-seed feed period.	2.68	14.41	15	5	3
	Average hay period, .	17.17	–	15	5	3

It was not considered advisable to feed more than from 12 to 15 pounds of the cotton-seed feed daily, and the additional quantity of coarse fodder was secured by adding from 2 to 5 pounds of hay, to suit the appetites of the various animals. We have, then, 12 to 15 pounds of cotton-seed feed, compared with a like amount of hay. The cotton-seed feed was mixed daily in the proportion of 4 pounds of hulls to 1 pound of meal. The hay was a mixture of grasses, with Timothy predominating. Some clover was scattered through the mixture.

Digestible Matter in Rations (Per Cent.).

	NAME.	Total Dry Matter.	DIGESTIBLE.				Nutritive Ratio.
			Protein.	Carbohydrates.	Fat.	Total.	
Cotton-seed period	Mary, . . .	23.20	2.45	10.58	.83	13.86	1 : 5.08
	Jennie, . . .	21.44	2.37	9.78	.76	12.91	1 : 4.85
	Nora, . . .	21.44	2.37	9.76	.81	12.94	1 : 4.85
	Beauty, . . .	25.83	2.57	11.82	.87	15.26	1 : 5.36
	Red, . . .	24.07	2.49	10.99	.85	14.33	1 : 5.60
	Spot, . . .	23.61	2.47	10.77	.83	14.07	1 : 5.08

Digestible Matter in Rations (Per Cent.) — Concluded.

	NAME.	Total Dry Matter.	DIGESTIBLE.				Nutritive Ratio.
			Protein.	Carbohydrates.	Fat.	Total.	
Hay period.	Mary, . . .	23.17	2.41	10.67	.56	13.64	1:4.95
	Jennie, . . .	21.42	2.33	9.85	.54	12.72	1:4.77
	Nora, . . .	21.42	2.33	9.85	.54	12.72	1:4.77
	Beauty, . . .	25.78	2.53	11.91	.60	15.04	1:4.30
	Red, . . .	24.08	2.45	11.08	.58	14.11	1:5.00
	Spot, . . .	24.08	2.45	11.08	.58	14.11	1:5.00
Average cotton-seed feed period.		23.26	2.45	10.62	.82	13.64	1:5.14
Average hay period, .		23.32	2.42	10.74	.57	13.72	1:5.00

The amounts and proportions of digestible matter in each of the two rations are identical. In calculating the above rations, average digestion coefficients were taken for the grains, the coefficients obtained at this station for the cotton-seed feed, and in case of the hay, the coefficients obtained by us for hay of similar appearance and composition. It must be remembered that the above digestible material in the two rations is only estimated. It is therefore quite possible that, had actual digestion experiments been made with the cows, these figures may have been somewhat modified.

Weight of Animals at Beginning and End of Experiment (Pounds).

		Mary.	Jennie.	Nora.	Beauty.	Red.	Spot.	Total Gain.
Cotton-seed period, .	Beginning, . .	768	818	745	943	1,006	1,007	–
	End, . . .	767	840	767	954	1,042	1,002	85
Hay period, . . .	Beginning, . .	829	897	757	946	1,096	954	–
	End, . . .	825	888	780	973	1,116	1,024	126

The cows were weighed at the same time for three consecutive days at the beginning and end of the experiment.

Four of the six cows were rather thin in flesh at the beginning of the test, and made gains on both rations. The hay period showed a herd increase of 41 pounds over the cotton-seed period.

Milk and Butter Yields (Pounds).

PERIOD.	Cows.	Total Milk.	Daily Milk.	Daily Quarts.	Total Milk Solids.	Total Fat.	Total Butter.	Daily Butter.
Cotton-seed period.	Mary,	596.88	21.32	9.92	83.38	28.29	33.00	1.18
	Jennie,	609.97	21.78	10.13	88.81	30.50	35.59	1.27
	Nora,	519.12	18.54	8.62	69.81	23.62	27.56	.98
	Beauty,	587.68	20.99	9.76	84.75	30.97	36.13	1.29
	Red,	549.94	19.64	9.13	67.63	21.28	24.82	.88
	Spot,	428.77	15.31	7.12	62.23	22.42	26.16	.93
Hay period.	Mary,	575.64	20.55	9.57	79.83	27.34	31.90	1.14
	Jennie,	527.12	18.82	8.75	80.49	30.46	35.54	1.27
	Nora,	613.34	21.89	10.17	80.77	24.78	28.91	1.03
	Beauty,	685.67	24.47	11.38	97.85	33.60	39.20	1.40
	Red,	557.00	19.89	9.25	69.62	22.72	26.51	.95
	Spot,	491.17	17.56	8.17	70.83	23.23	27.10	.97
Average cotton-seed feed ration.		548.73	19.59	9.10	76.10	26.18	30.54	1.09
Average hay ration,		574.99	20.53	9.55	79.90	27.02	31.53	1.13
Percentage increase hay over cotton-seed period.		4.6+	-	-	4.8+	3.1+	-	-

In this experiment, the results are the reverse of those obtained in the first test, the hay period yielding several per cent. more milk, milk solids and fat. Our observations of the animals from day to day during the trial indicated that the cotton-seed feed ration was falling slightly behind the hay ration. The animals, being in the early part of the lactation period, would naturally be more sensitive to the effect of food than in the latter portion of the period of lactation.

Dry and Digestible Matter required to produce Milk and Butter (Per Cent.).

DRY MATTER REQUIRED TO PRODUCE —	Cotton-seed Period.	Hay Period.	Digestible Matter required to produce —	Cotton-seed Period.	Hay Period.
100 pounds milk, . .	118.70	113.60	100 pounds milk, .	70.90	66.90
1 pound milk solids, .	8.56	8.18	1 pound milk solids, .	5.11	4.81
1 pound milk fat, . .	24.88	24.17	1 pound milk fat, .	14.86	14.22
1 pound butter, . .	21.38	20.70	1 pound butter, . .	12.77	12.18

Market Cost of Feed Stuffs.

Wheat bran, ...	$14 00	per ton.
Chicago gluten meal, ...	18 00	"
Mangolds, ...	3 00	"
Hay, ...	15 00	"
Cotton-seed feed, ...	15 00	"

Cost of Feed to produce Milk and Butter. Average for Six Cows (Cents).

	Daily Feed.	100 Pounds Milk.	Quart Milk.	Pound Butter Fat.	Pound Butter.
Cotton-seed period, ...	21.32	110.6	2.38	23.40	20.10
Hay period, ...	21.32	104.9	2.26	22.69	19.33
Increased percentage cost of cotton-seed over hay period.	-	5.2+	-	-	3.2+

The cotton-seed rations slightly increased the cost of the milk and butter.

D. AVERAGE RESULTS FROM TWO EXPERIMENTS.

It is thought desirable to bring together the results of both experiments, believing that they will give a fair representation of the relative values of like quantities of cotton-seed feed and a good quality of hay.

1. *Total Live Weight gained by the Six Cows in Both Experiments (Pounds).*

Cotton-seed feed periods, ...	95
Hay periods, ...	166

2. *Average Dry and Digestible Matter Consumed Daily (Pounds).*

	Total Dry Matter.	Digestible.				Nutritive Ratio.
		Protein.	Fat.	Carbohydrates.	Total.	
Cotton-seed period,	22.57	2.32	.82	10.39	13.40	1 : 5.35
Hay period,	22.65	2.41	.59	10.61	13.61	1 : 5.00

These figures show very slight variations.

3. *Total Milk and Butter Yields (Pounds).*

	Milk.	Milk Solids.	Milk Fat.	Butter.
Cotton-seed period,	5867	823.5	290.4	338.8
Hay period,	5933	826.3	281.1	328.0
Percentage increase hay over cotton-seed,	1.1+	.34+	3.2—	3.2—

These variations can be regarded as within the limits of experimental error.

4. *Average Feed Cost of Milk and Butter (Cents).*

	Daily Cost of Feed.	100 Pounds Milk.	Quart Milk.	Pound Butter Fat.	Pound Butter.
Cotton seed period,	20.19	102.6	2.20	20.79	17.79
Hay period,	20.14	102.5	2.19	21.80	18.63
Percentage increased cost of hay over cotton-seed.	±	±	±	4.63+	4.5+

The 4.6 percentage increased cost of butter in the hay period is due to the rather unexpected results in the first experiment.

5. *Dry and Digestible Matter required to produce Milk and Butter.*

I. Dry Matter (Pounds).

	100 Pounds Milk.	Pound Milk Solids.	Pound Butter Fat.	Pound Butter.
Cotton-seed period,	112.9	8.04	22.79	19.56
Hay period,	112.6	8.08	23.72	20.37

II. Digestible Matter (Pounds).

	100 Pounds Milk.	Pound Milk Solids.	Pound Butter Fat.	Pound Butter.
Cotton-seed period, ...	67.65	4.81	13.65	11.72
Hay period, ...	67.69	4.85	14.25	12.22

General Conclusions.

Cotton-seed feed, from its appearance, is certainly not an attractive looking article for consumption. The cotton-seed hulls, comprising the bulk of the feed, consists of the dark seed coats, together with an entangling mass of fibre. They are difficult to masticate, and quite indigestible. The cotton-seed meal with which the hulls are mixed imparts its flavor to the material, and actually increases the digestibility of the hulls. In our experiments we have had no trouble in inducing animals to eat 12 to 15 pounds daily within three or four days. The two experiments have shown cotton-seed feed to give as large milk and butter yields, at as low a cost, as a good quality of hay. The writer is of the opinion, however, that this feed requires more energy for its digestion than hay, and, when fed for any length of time, would have a tendency to induce digestive disturbances. A mixture of hulls and meal could probably be turned to better account for fattening steers than as a continuous feed for dairy cows. Massachusetts farmers could derive no benefit from feeding this material in place of hay. For those who are obliged to purchase all of their coarse feeds, it might be desirable to use one-half of this material in place of hay, provided it could be purchased for somewhat less money. Cotton-seed feed should be consumed where it is produced. For the farmers of the south it is undoubtedly a cheap source of coarse feed, and, when fed in moderate quantities, will unquestionably return good results.

ANALYTICAL DATA.

Dry Matter Determinations (Per Cent.).

Experiment I.

	Hay.	Millet and Soy Bean Ensilage.	Cotton seed-Feed.	Wheat Bran.	Linseed Meal.	Peoria Gluten Feed.
April 8 through April 28, .	90.33	18.79	89.00	87.89	90.58	93.04
May 11 through May 31, .	89.84	20.58	88.10	87.86	90.48	93.23

Experiment II.

	Hay.	Mangolds.	Cotton-seed Feed.	Wheat Bran.	Chicago Gluten Meal.
Hay * and cotton-seed periods, . .	87.60	8.00	87.8	87.2	90.6

* The dry matter determinations varied so little in the two halves of this experiment that the average in each case was taken.

Composition of Feeds (Per Cent.).

Experiment I.

	Hay.	Millet and Soy Bean Ensilage.	Cotton-seed Feed.	Wheat Bran.	Linseed Meal.	Peoria Gluten Feed.
Ash, ...	5.94	12.77	3.82	6.42	4.94	1.07
Fibre, ...	32.00	34.02	39.67	11.37	7.26	7.13
Fat, ...	3.07	2.59	3.90	5.73	7.05	7.59
Protein, ...	11.07	9.40	13.02	18.68	41.99	23.83
Extract matter, . . .	47.92	41.22	39.59	57.80	38.76	60.38

Experiment II.

	Hay.	Mangolds.	Cotton-seed Feed.	Wheat Bran.	Chicago Gluten Meal.
Ash, ...	5.78	15.49	3.51	7.11	1.52
Fibre, ...	33.98	10.67	40.69	12.08	3.21
Fat, ...	2.68	.73	3.69	5.69	7.38
Protein, ...	8.41	14.35	11.98	18.12	40.38
Extract matter, ...	49.15	58.76	40.13	57.00	47.51

Coefficients of Digestibility.

Experiment I.

	Hay.	Ensilage.	Cotton-seed Feed.	Wheat Bran.	Linseed Meal.	Peoria Gluten Feed.	Chicago Gluten Meal.	Mangolds.
Fibre,	66	69	59	22	57	78	-	-
Fat,	53	72	89	71	89	79	-	-
Protein,	62	57	39	78	89	83	-	-
Extract Matter,	64	59	58	68	78	90	-	-

Experiment II.

Fibre,	58	-	55	22	-	-	-	43
Fat,	50	-	93	68	-	-	93	-
Protein,	54	-	42	79	-	-	89	75
Extract Matter,	56	-	59	69	-	-	93	91

Composition of Milk (Per Cent.).

Experiment I.

	ADA.		RED SPOT.		BESSIE	
	Solids.	Fat.	Solids.	Fat	Solids.	Fat.
Cotton-seed period,	13.84	4.93	14.01	4.84	13.63	4.93
	13.82	5.00	14.48	5.59	-	-
Average,	13.83	4.96	14.24	5.21	13.63	4.93
Hay period,	13.57	4.62	13.95	4.64	13.26	4.53
	-	-	-	-	13.47	4.52
Average,	13.57	4.62	13.95	4.64	13.36	4.52

Experiment I. — Concluded.

	BEAUTY.		RED.		SPOT.	
	Solids.	Fat.	Solids.	Fat.	Solids.	Fat.
Cotton-seed period, . .	15.08	5.62	14.03	5.05	14.88	5.33
	–	–	–	–	15.28	5.48
Average, . . .	15.08	5.62	14.03	5.05	15.08	5.40
Hay period, . . .	14.54	5.13	13.91	4.72	14.77	5.27
	14.61	5.05	13.87	4.60	–	–
Average, . . .	14.57	5.09	13.89	4.66	14.77	5.27

Experiment II.

	MARY.		JENNIE.		NORA.	
	Solids.	Fat.	Solids.	Fat.	Solids.	Fat.
Cotton-seed period, . .	13.96	4.64	14.36	4.73	13.39	4.48
	13.81	4.80	14.58	5.33	13.44	4.58
	14.20	4.93	14.58	4.92	13.52	4.63
	13.91	4.74	14.73	5.00	13.45	4.50
Average, . . .	13.97	4.74	14.56	5.00	13.45	4.55
Hay period, . . .	13.76	4.73	14.79	5.45	13.00	3.81
	13.86	4.75	15.39	5.88	12.93	4.10
	14.01	4.85	15.55	6.00	13.46	4.17
	13.85	4.68	15.37	5.78	13.28	4.07
Average, . . .	13.87	4.75	15.27	5.78	13.17	4.04

Experiment II. — Concluded.

	BEAUTY.		RED.		SPOT.	
	Solids.	Fat.	Solids.	Fat.	Solids.	Fat.
Cotton-seed period, . .	14.62	5.35	12.48	3.89	14.57	5.08
	13.95	4.85	11.88	3.93	14.77	5.05
	14.66	5.48	12.60	4.02	14.92	5.15
	14.46	5.40	12.23	3.63	13.90	5.63
Average, . . .	14.42	5.27	12.30	3.87	14.54	5.23
Hay period, . . .	-	-	12.26	4.00	14.01	4.34
	14.12	4.93	12.41	4.05	14.14	4.75
	14.49	4.97	12.74	4.20	14.59	4.94
	14.19	4.80	12.53	4.08	14.94	4.91
Average, . . .	14.27	4.90	12.49	4.08	14.42	4.73

Average Results of Six Cows.

	EXPERIMENT I.		EXPERIMENT II.	
	Solids.	Fat.	Solids.	Fat.
Cotton-seed period, ...	14.31	5.18	13.87	4.78
Hay period, ...	14.02	4.80	13.91	4.71

Each distinct analysis represents a composite sample from 8 different milkings. In Experiment I., samples were taken for four days of the last two weeks only. In Experiment II., each analysis represents the comparison of the milk for each of the four weeks.

REPORT OF THE ENTOMOLOGIST.

CHARLES H. FERNALD.

Two bulletins have been issued from this department during the year, — one on the habits, food and economic value of the American toad (*Bufo lentiginosus americanus*), and one on the brown-tail moth (*Euproctis chrysorrhœa*). I have been able in the intervals of other duties to prepare a monograph of the plume-moths (*Pterophoridæ*) of North America, which is published with illustrations in the thirty-fifth annual report of the college. A large amount of time has also been devoted to the work on the gypsy moth in the eastern part of the State.

SAN JOSÉ SCALE.

The San José scale (*Aspidiotus perniciosus*) has appeared in many places in Massachusetts, having been received on nursery stock from nurseries both in this and in other States. In the early part of the season my assistants visited, as far as possible, all the nurseries in the State, and carefully examined them for this scale. Most of them appeared to be entirely free from this insect, but a few were more or less infested. The owners of these infested nurseries have taken the most active measures to destroy this pest, under the supervision of one of my assistants. Many of the nurserymen do not raise a sufficient amount of stock to supply all of their orders, and often purchase from outside sources. This stock is often received and sent out without examination, and in this way it is possible for the San José scale to be distributed by those whose nurseries are not infested. A bulletin on the San José scale will be published as soon as other duties will permit, in which will be given a more complete account of the condition of the nurseries visited, together with the measures taken to eradicate the pest.

The scale insects have been and are still being introduced into this country from other parts of the world, and in this way we are liable at any time to find new or unknown species on our fruit or ornamental trees and shrubs and in our greenhouses. It therefore seems wise to learn as much as possible about these insects, in order that we may know what to do with those already here, and any that may hereafter be brought into this country. To this end, more than six hundred circular letters were sent out to all entomologists whose names and addresses could be obtained, asking for specimens of two genera of the scale insects, and already a large amount of material has been received. Prof. R. S. Lull has undertaken to work up and prepare a monograph of the genus *Pulvinaria*, and Mr. R. A. Cooley a monograph of the genus *Chionaspis*. Very commendable progress has already been made by these two gentlemen.

ARMY WORM.

During the summer of 1896 the army worm (*Leucania unipuncta*) was very abundant in Amherst and in many other parts of the State, often in destructive numbers, and in the correspondence with this department information concerning this insect was asked for more than of all others combined. During the summer of 1897, however, the army worm seems to have been present in so few numbers as to have done no harm, and it was not referred to in a single letter received by me. It is a well-known fact that this insect has never in the past appeared in destructive numbers two years in succession in the same place, and the past season seems to have been no exception. The caterpillars were reported in many cases to have been more or less infested with the eggs of a parasitic fly. These eggs no doubt hatched and the young maggots made their way into the caterpillars and destroyed them, thus reducing the army worm to insignificant numbers, so that the few remaining have been entirely overlooked.

PLANT LICE.

While the army worm has been very scarce during the past season, the aphids or plant lice have been very abundant on trees and shrubs, and many letters have been received, asking how to destroy them. The best method, so far as known, is to spray the trees with kerosene emulsion ; but in spraying it is very difficult to reach every insect, and, as they multiply very rapidly, they soon become as abundant as ever, and it becomes necessary to spray the trees or shrubs repeatedly after short intervals.

Tobacco Cutworm.

Early in the season cutworms were said to be destroying the young tobacco plants in the tobacco fields of the Connecticut valley, and specimens that were brought in and bred to maturity developed into moths which proved to be *Carneades messoria.* The caterpillars of this species partake of a rather varied diet, consisting not only of tobacco, but also of cabbage, corn, potatoes, spinach, onions, lettuce and fruit trees. The usual method taken by our tobacco growers, so far as I can learn, is to reset tobacco plants where they have been cut off by the worms, and at the same time dig out and destroy the worm that has done the mischief.

Canker Worms.

Four years ago canker worms began to increase so rapidly in this town that public attention was called to them, and a general account of the species occurring in Massachusetts was given with illustrations in Bulletin No. 20, published in January, 1893. In that bulletin the usual remedies were given. These consisted of tacking bands of heavy paper around the trunks of the trees and painting these bands with prepared printers' ink, repainting with the ink as often as it became dry or hardened enough to permit the females to cross the band. The method of protecting the trees with oil troughs of zinc or tin around the trunks was also mentioned. It was finally stated that probably the most effectual method was to spray the trees with Paris green in water as soon as the eggs hatched in the spring. A further account of canker worms was given in Bulletin No. 28, published in April, 1895.

A careful study of the different methods used to destroy these insects, which are so prevalent in many parts of this Commonwealth, has been made on thirteen apple trees on my own premises in Amherst. Three years ago these trees were carefully banded with heavy paper and painted with Morrill's tree ink early in the spring, when the first females began to ascend the trees, and the painting was repeated as often as necessary. It was found that the ink would often harden on the trees even during the night following the application, and remain hard on the shady side long enough in the morning for some of the females to ascend the tree on that side, so that this method did not prove to be a perfect protection. The cost of the materials and of their application averaged about fifty cents to each tree.

The oil troughs are also quite expensive, and often leak so that the rain displaces the oil and then evaporates, allowing the females to ascend the trees; or spiders spin their webs across beneath the overhanging protection, forming a bridge on which the moths may easily pass, so that this device does not form a perfect protection.

Two years ago these trees were sprayed with Paris green in water, in the proportion of one pound to one hundred and fifty gallons, at a cost of five cents a tree, allowing fifteen cents an hour for labor. There was a strong wind blowing, and more time was required to do the work than would otherwise have been the case. Last year the same trees were sprayed with Paris green, in the same proportion as before. At this time it was nearly calm, and the cost of spraying was three cents a tree. The contrast between these trees and those on adjacent lots were very marked, for the sprayed trees retained their foliage and yielded a full crop, while the unsprayed trees were stripped of leaves, and bore no fruit. These trees were sprayed but once, and this method appears to have been more effectual and far cheaper than the others. In case of rain it might be necessary to repeat the spraying, but even then it would be the cheaper method.

REPORT OF THE CHEMIST.

DEPARTMENT OF FERTILIZERS AND FERTILIZER MATERIALS.

CHARLES A. GOESSMANN.

Assistants: HENRI D. HASKINS, CHARLES I. GOESSMANN, GEORGE D. LEAVENS.

I. Report on Official Inspection of Commercial Fertilizers.
II Report on General Work in the Chemical Laboratory.
III. Observations with Special Fertilizers on Tobacco raised in Massachusetts.

I. REPORT ON OFFICIAL INSPECTION OF COMMERCIAL FERTILIZERS AND AGRICULTURAL CHEMICALS IN 1897.

CHARLES A. GOESSMANN.

Sixty-six manufacturers and dealers in commercial fertilizers and agricultural chemicals have secured, during the past year, licenses for the sale of their goods in the State. Thirty-six of these parties have offices for the general distribution of their goods in Massachusetts; the remainder reside in other States, — ten in New York, six in Connecticut, three in Rhode Island, three in Vermont, two in Pennsylvania, one in Maryland, one in Illinois, one in Ohio and three in Canada.

The number of distinct brands licensed, including agricultural chemicals, amounted to two hundred and ninety.

The collecting and sampling of the material for official analyses were in charge of Mr. R. H. Smith, a graduate of the Massachusetts Agricultural College in the class of 1892, who since his graduation has been an efficient assistant in the chemical laboratory of the experiment station for the examination of commercial fertilizers.

Four hundred and fifteen samples of fertilizer have thus far been collected during the present year; of these, three hundred and one samples, representing two hundred and twenty-three distinct brands, were analyzed by the close of the month of November, and the results published in July and November bulletins, Nos. 48 and 49, of the Hatch Experiment Station of the Massachusetts Agricultural College. The remaining samples, in common with others coming under our observation before the expiration of the licenses, will be analyzed in due time, and the results published in conformity with our laws for the regulation of the trade in commercial fertilizers.

The results of the inspection during the past season are, on the whole, quite satisfactory, and if anything are an improvement on the results of the preceding year. The beneficial results of improved machinery and of improved skill in the management of the manufacture of fertilizers show themselves in a marked degree when compared with the general character of commercial fertilizers in earlier periods of the business.

To render the actual conditions of the trade in commercial fertilizers during the past season more prominent, a summary of our results is here inserted. In reading the subsequent statement, it has to be remembered that only the lowest stated guarantee is legally binding in all sales: —

(*a*) Where three essential elements of plant food were guaranteed: —

Number with three elements equal to or above the highest guarantee,	3
Number with two elements above the highest guarantee,	2
Number with one element above the highest guarantee,	60
Number with three elements between the lowest and highest guarantee,	69
Number with two elements between the lowest and highest guarantees,	63
Number with one element between the lowest and highest guarantees,	16

Number with two elements below the lowest guarantee,	6
Number with one element below the lowest guarantee,	29

(*b*) Where two essential elements of plant feed were guaranteed: —

Number with two elements above the highest guarantee,	3
Number with one element above the highest guarantee,	10
Number with two elements between the lowest and highest guarantees,	13
Number with one element between the lowest and highest guarantees,	12
Number with one element below the lowest guarantee,	6
Number with two elements below the lowest guarantee,	3

(*c*) Where one essential element of plant food was guaranteed: —

Number above the highest guarantee,	10
Number between the lowest and highest guarantees,	23
Number below the lowest guarantee,	1

The modes of analyses adopted in this work were in all essential points those recommended by the Association of Official Chemists.

Attention has been called, in previous reports, to the fact that the introduction of a more liberal amount of potash into the make-up of a large class of so-called complete manures has become from year to year more general. This change has been slow but decided, and in a large degree may be ascribed to the daily increasing evidence, resulting from actual observations in field and garden, that the farm lands of Massachusetts are frequently especially deficient in potash compounds, and consequently need in many instances a more liberal supply of available potash from outside sources to give satisfactory returns. Whenever garden vegetables, fruits and forage crops constitute the principal products of the land, this recent change in the mode of manuring deserves a particularly careful trial; for the crops raised consume exceptionally large quantities of potash, as compared with grain crops. In view of these facts, it will be conceded that a system of manuring farm and garden which tends to meet the more satisfactory recognized conditions of large areas of land, as well as the special wants of important growing branches of agricultural industries, is a movement in the right direction.

In repeating these statements, it is not assumed that it will remain economical to continue the practice after a repeated application of a liberal amount of potash, without some special reason.

To restore to the soil those essential manurial constituents which the crops carry off is a safe rule to follow in the effort to secure the maintenance of the fertility of the soil; yet to obtain this result in the most economical way will always remain the ultimate aim of farming as a business enterprise.

A judicious management of the trade in commercial fertilizers implies a due recognition of results well established by experiment, regarding the requirements of a remunerative production of farm and garden crops; yet, as the manufacturer at best can only prepare the composition of his special fertilizers on general lines, not knowing the particular condition and character of the soil which ultimately receives them, it becomes of the utmost importance on the part of the farmer to make himself acquainted with his special wants of manurial substances, and to thus qualify himself for a more judicious selection from the various fertilizers offered for purchase.

The present condition of the trade in commercial fertilizers offers exceptional advantages to provide efficient manures for the raising of farm and garden crops of every description congenial to soil and climate. The various essential articles of plant food, as potash, phosphoric acid and nitrogen compounds, are freely offered for sale in forms suitable to render, by their addition, the different kinds of manurial refuse matter of the farm in a higher degree fit to meet the special wants of the crops to be raised.

As the physical conditions and chemical resources of soils on available plant food frequently differ widely even on the same farm, no definite rule can be given for manuring farm lands, beyond the advice to return to the soil in available form those plant constituents which the crops raised during the preceding years have abstracted in exceptionally large proportion, and which will be especially called for by the crops to be raised.

An intelligent selection of fertilizers from among the various brands offered for sale requires, in the main, two kinds of knowledge; namely, that the brand of fertilizer in question actually contains the guaranteed quantities and qualities of essential articles of plant food at a reasonable cost, and that it contains them in such form and proportions as will best meet under existing circumstances the special wants of soil and crop.

In some cases it may be only phosphoric acid or nitrogen or potash; in others, two of them; and in others again, all three. A remunerative use of commercial fertilizers can only be secured by attending carefully to these considerations.

To assist farmers in selecting their fertilizers with reference to the wants of the crops they wish to cultivate, the writer has for years published in his annual reports a compilation of the analyses of farm and garden crops, to serve as a guide to all interested in a rational mode of manuring plants. Copies of these compilations of analyses may be secured by asking for them at the office of the Hatch Experiment Station at Amherst, Mass.

An economical use of manurial substances from any source is only possible after the local condition of the soil under consideration, as well as the special wants of the crops to be raised, have been duly considered. It becomes the business of every progressive farmer to acquire such information as is called for to select intelligently, from the various manurial resources at his disposal, those materials which will meet best his wants for a complete fertilizer.

In making choice from among the so-called complete fertilizers, two points seem to be in particular worth remembering. First, select them with reference to the amount, the quality and the kind of essential constituents they are guaranteed to contain, and not merely with reference to cost per ton; mere trade names are no guarantee of fitness. High-priced articles, when offered by reputable manufacturers, have proved in many instances cheaper than low-priced goods. Second, buy your supplies of reputable dealers, and insist in all cases on a statement of guaranteed composition.

The majority of manufacturers and dealers in commercial fertilizers in Massachusetts have been for years on record, regarding the character of their goods, in the published reports of the State inspector, which are open to the public; to these records this office invariably refers all parties asking for information in that direction.

Valuation of Commercial Fertilizers.

The market value of the higher grades of agricultural chemicals and compound fertilizers depends in the majority of cases on the amount and the particular form of three essential articles of plant food which they contain, *i.e.*, nitrogen, potash and phosphoric acid. Supply and demand control the temporary market prices not less in the fertilizer trade than in other lines of commercial business.

The approximate market value of a fertilizer, simple or compound, is obtained by multiplying the pounds contained in a ton of two thousand pounds by the trade value per pound of each of the three above-stated essential constituents of plant food present. The same course is adopted with reference to the different forms of each, wherever different prices are recognized in the trade. Adding the different values per ton obtained, we find the total value per ton at the principal place of distribution.

As farmers are quite frequently not in the position to secure the desired information regarding the market cost of fertilizers they wish to secure, the official inspectors of commercial fertilizers have aided them for years in ascertaining the current market prices of the following leading or standard raw materials: —

Sulphate of ammonia.
Nitrate of soda.
Muriate of potash.
Sulphate of potash.
Cotton-seed meal.
Dry ground fish.
Azotin.
Ammoniate.
Castor pomace.
Linseed meal.
Dried blood.
Dried ground meat.
Bone and tankage.
Plain superphosphates, etc.

Which serve largely in the manufacture of good fertilizers for our market; and have published the results of their inquiries in form of tables, stating the average trade values per pound, for the six months preceding, of the different kinds and forms of fertilizing materials at the leading places of distribution.

The market value of fertilizing ingredients, like other merchandise, is liable to changes during the season. The values stated below are based on the condition of the fertilizer market in centres of distribution in New England during the six months preceding March, 1897: —

Trade Values of Fertilizing Ingredients in Raw Materials and Chemicals, 1897 (Cents per Pound).

Nitrogen in ammonia salts,	13.5
Nitrogen in nitrates,	14.0
Organic nitrogen in dry and fine-ground fish, meat, blood and in high-grade mixed fertilizers,	14.0
Organic nitrogen in cotton-seed meal, linseed meal and in castor pomace,	12.0
Organic nitrogen in fine-ground bone and tankage,	13.5
Organic nitrogen in medium-ground bone and tankage,	11.0
Organic nitrogen in coarse bone and tankage,	8.0
Phosphoric acid soluble in water,	5.5
Phosphoric acid soluble in ammonium citrate,	5.0
Phosphoric acid in fine bone and tankage,	5.0
Phosphoric acid in medium bone and tankage,	4.0
Phosphoric acid in coarse bone and tankage,	2.5
Phosphoric acid in fine-ground fish, cotton-seed meal, linseed meal, castor pomace and wood ashes,	5.0
Phosphoric acid insoluble (in am. cit.) in mixed fertilizers,	2.0
Potash as sulphate, free from chlorides,	5.0
Potash as muriate,	4.5

From these figures it is apparent that the best forms of nitrogen and phosphoric acid have suffered a material reduction in cost, as compared with preceding years.

The market value of low-priced materials used for manurial purposes, as salt, wood ashes, various kinds of lime, barn-yard manure, factory refuse and waste materials of various description, quite frequently does not stand in a close relation to the current market value of the amount of essential articles of plant food they contain. Their cost varies in different localities. Local facilities for cheap transportation, and more or less advantageous mechanical conditions for speedy action, exert, as a rule, a decided influence on their selling price.

The mechanical condition of any fertilizing material, simple or compound, deserves the most serious consideration of farmers when articles of a similar chemical character are offered for their choice. The degree of pulverization controls, almost without exception, under similar conditions, the rate of solubility, and the more or less rapid diffusion of the different articles of plant food throughout the soil.

The state of moisture exerts a no less important influence on the pecuniary value in case of one and the same kind of substance. Two samples of fish fertilizers, although equally pure, may differ from fifty to one hundred per cent. in commercial value, on account of mere difference in moisture.

Crude stock for the manufacture of fertilizers, and refuse materials of various descriptions, have to be valued with reference to the market price of their principal constituents, taking into consideration at the same time their general fitness for speedy action.

Consumers of commercial manurial substances will do well to buy, whenever practicable, on a guarantee of composition of their essential constituents, and to see to it that the bill of sale recognizes the point of the bargain. Any mistake or misunderstanding in the transaction may be readily adjusted, in that case, between the contending parties. The responsibility of the dealer ends with furnishing an article corresponding in its composition with the lowest stated quantity of each specified essential constituent.

It is of the first importance, when buying fertilizers for home consumption, to consider their cost with reference to what they promise to furnish.

List of Manufacturers and Dealers who have secured Certificates for the sale of Commercial Fertilizers in the State during the Past Year (May 1, 1897, to May 1, 1898) and the Brands licensed by Each.

The Armour Fertilizer Works, Chicago, Ill.: —
- Bone Meal.
- Bone and Blood.
- Ammoniated Bone and Potash.
- All Soluble.
- Bone, Blood and Potash.
- Grain Grower.

American Fertilizer Co., Boston, Mass.: —
- Alkali Nitrate Phosphate for Hoed Crops.

American Fertilizer Co. — *Con.*
- Alkali Nitrate Phosphate for Grass and Grain.
- General American Fertilizer.
- Potato Fertilizer.

Wm. H. Abbott, Holyoke, Mass.: —
- Eagle Brand for Grass and Grain.
- Complete Tobacco Fertilizer.
- Animal Fertilizer.

American Cotton Oil Co., New York, N. Y.: —
- Cotton-seed Meal.

Bartlett & Holmes, Springfield, Mass.: —
- Pure Ground Bone.
- Animal Fertilizer.
- Tankage.

H. J. Baker & Bro., New York, N. Y.: —
- Pure Ground Bone.
- Standard Un X Ld Fertilizer.
- Strawberry Manure.
- Potato Manure.
- Tobacco Manure.
- Grass and Grain Manure.
- A. A. Ammoniated Superphosphate.
- Harvest Home Fertilizer.

C. A. Bartlett, Worcester, Mass.: —
- Fine-ground Bone.
- Animal Fertilizer.

Berkshire Mills Co., Bridgeport, Conn :—
- Complete Fertilizers.
- Ammoniated Bone Phosphate.

Bowker Fertilizer Co., Boston, Mass.: —
- Stockbridge Special Manures.
- Hill and Drill Phosphate.
- Farm and Garden Phosphate.
- Lawn and Garden Dressing.
- Fish and Potash.
- Potato and Vegetable Manure.
- Potato Phosphate.
- Market Garden Manure.
- Sure Crop Phosphate.
- Gloucester Fish and Potash.
- High-grade Fertilizer.
- Essex Fertilizer.
- Bone and Wood Ash Fertilizer.
- Nitrate of Soda.
- Dried Blood.
- Dissolved Bone-black.
- Muriate of Potash.
- Sulphate of Potash.

William E. Brightman, Tiverton, R.I.: —
- Potato and Root Manure.
- Phosphate.
- Fish and Potash.

Bradley Fertilizer Co., Boston, Mass.: —
- X. L. Superphosphate.
- Potato Manure.
- B. D. Sea Fowl Guano.
- Complete Manures.
- Fish and Potash.
- High-grade Tobacco Manure.
- English Lawn Fertilizer.
- Ammoniated Bone Phosphate.
- Breck's Lawn and Garden Dressing.
- Sulphate of Potash.

Bradley Fertilizer Co. — *Con.*
- Muriate of Potash.
- Nitrate of Soda.
- Sulphate of Ammonia.
- Dissolved Bone-black.
- Fine-ground Bone.

Daniel T. Church, Providence, R. I. (E. Wilcox, general agent): —
- Church's B Special.
- Church's C Standard.
- Church's D Fish and Potash.

The Cleveland Linseed Oil Co., Cleveland, O.: —
- Screened Linseed Meal.

Clark's Cove Fertilizer Co., Boston, Mass.: —
- Bay State Fertilizer.
- Bay State Fertilizer G. G. Brand.
- Great Planet Manure.
- Potato and Tobacco Fertilizer.
- King Philip Guano.
- Potato Manure.
- Fish and Potash.
- White Oak Pure Bone Meal.

Cleveland Dryer Co., Boston, Mass.: —
- Superphosphate.
- Potato Phosphate.
- Cleveland Fertilizer.

E. Frank Coe Co., New York, N. Y.: —
- High-grade Potato Fertilizer.
- Bay State Ammoniated Bone Super phosphate.
- Bay State Potato Manure.
- High-grade Ammoniated Bone Superphosphate.
- Gold Brand Excelsior Guano.
- Fish Guano and Potash.

Crocker Fertilizer and Chemical Co., Buffalo, N. Y.: —
- Ammoniated Bone Superphosphate.
- Potato, Hop and Tobacco Phosphate.
- Ammoniated Wheat and Corn Phosphate.
- New Rival Ammoniated Superphosphate.
- Practical Ammoniated Superphosphate.
- Vegetable Bone Superphosphate.
- General Crop Phosphate.
- Universal Grain Grower.
- Special Potato Manure.
- New England Tobacco and Potato Grower.

Crocker Fertilizer and Chemical Co. — *Con.*
- Coolidge Bros. Special Truck Fertilizer.
- A. A. Complete Manure.
- Ground Bone Meal.
- Pure Ground Bone.
- Muriate of Potash.
- Nitrate of Soda.

Cumberland Bone Phosphate Co., Boston, Mass.: —
- Superphosphate.
- Potato Fertilizer.
- Concentrated Phosphate.
- Guano.

City Florist, Brockton, Mass.: —
- Boo Boo Plant Food.

L. B. Darling Fertilizer Co., Pawtucket, R. I.: —
- Animal Fertilizer.
- Potato and Root Crop Manure.
- Lawn Dressing.
- Tobacco Grower.
- Blood, Bone and Potash.
- Special Formula.
- Fine-ground Bone.
- Muriate of Potash.
- Nitrate of Soda.

John C. Dow & Co., Boston, Mass.: —
- Ground Bone Fertilizer.
- Nitrogenous Superphosphate.
- Pure Ground Bone.

W. E. Fife & Co., Clinton, Mass.: —
- Wood Ashes.

Great Eastern Fertilizer Co., Rutland, Vt.: —
- Northern Corn Special.
- General Fertilizer.
- Vegetable Vine and Tobacco Fertilizer.
- Garden Special.
- Soluble Bone and Potash.

Thomas Hersom & Co., New Bedford, Mass.: —
- Bone Meal.
- Meat and Bone.

Alonzo P. Henderson, Hanover, Mass.: —
- Acme Brand Fertilizer.

Edmund Hersey, Hingham, Mass.: —
- Ground Bone.

John G. Jefferds, Worcester, Mass.: —
- Animal Fertilizer.
- Potato Manure.
- Fine-ground Bone.

Thomas Joint, St. Helen, Ontario, Can.: —
- Unleached Hard-wood Ashes.

Thomas Kirley, South Hadley Falls, Mass.: —
- Pride of the Valley.

A. Lee & Co., Lawrence, Mass.: —
- Lawrence Fertilizer.

Lowell Fertilizer Co., Boston, Mass.: —
- Bone Fertilizer for Corn and Grain.
- Complete Manure for Vegetables.
- Animal Fertilizer.
- Potato Phosphate.
- Bone and Potash.
- Lawn Dressing.
- Tobacco Manure.
- Empire Fertilizer.

Lowe Bros. & Co., Fitchburg, Mass.: —
- Tankage.

F. L. Lalor, Dunville, Ontario, Can.: —
- Canada Unleached Hard-wood Ashes.

The Mapes Formula and Peruvian Guano Co., New York, N. Y.: —
- Bone Manures.
- Superphosphates.
- Special Crop Manures.
- Sulphate of Potash.
- Double Manure Salts.
- Nitrate of Soda.

E. McGarvey & Co., London, Ontario, Can.: —
- Unleached Hard-wood Ashes.

McQuade Bros., West Auburn Mass.: —
- Fine-ground Bone.

Geo. L. Monroe, Oswego, N. Y.: —
- Canada Unleached Hard-wood Ashes.

National Fertilizer Co., Bridgeport, Conn.: —
- Complete Fertilizers.
- Ammoniated Bone.

National Fertilizer Co. — *Con.*
- Market-garden Manure.
- Potato Phosphate.
- Fish and Potash.
- Ground Bone.

Niagara Fertilizer Works, Buffalo, N. Y.: —
- Wheat and Corn Producer.
- Grain and Grass Grower.
- Potato, Tobacco and Hop Fertilizer.
- Niagara Triumph.

New England Dressed Meat and Wool Co., Boston, Mass.: —
- Sheep Fertilizer.

Packers Union Fertilizer Co., New York, N. Y.: —
- Universal Fertilizer.
- Wheat, Oats and Clover Fertilizer.
- Animal Corn Fertilizer.
- Potato Manure.
- Gardener's Complete Manure.

Pacific Guano Co., Boston, Mass : —
- Soluble Pacific Guano.
- Special Potato Manure.
- Special for Potatoes and Tobacco.
- Nobsque Guano.
- High-grade General Fertilizer.

Parmenter & Polsey Fertilizer Co., Peabody, Mass.: —
- Plymouth Rock Brand.
- Star Brand Fertilizer.
- Butman Brand Fertilizer.
- Special Potato.
- Strawberry.
- Ground Bone.
- Muriate of Potash.
- Sulphate of Potash.
- Nitrate of Soda.

A. W. Perkins & Co., Rutland, Vt.: —
- Plantene.

Prentiss, Brooks & Co., Holyoke, Mass.: —
- Complete Manures.
- Phosphate.
- Nitrate of Soda.
- Muriate of Potash.
- Sulphate of Potash.

Preston Fertilizer Co., Brooklyn, N. Y.: —
- Ammoniated Bone Superphosphate.

Quinnipiac Co., Boston, Mass.: —
- Phosphate.
- Potato Manure.
- Market-garden Manure.
- Fish and Potash.
- Havana Tobacco Grower.
- Grass Fertilizer.
- Corn Manure.
- Potato Phosphate.
- Onion Manure.
- Pure Ground Bone.
- Dry Ground Fish.
- Muriate of Potash.
- Sulphate of Potash.
- Nitrate of Soda.
- Sulphate of Ammonia.
- Dissolved Bone-black.

Read Fertilizer Co., New York, N. Y. (H. D. Foster, general agent): —
- Standard Fertilizer.
- High-grade Farmers' Friend.
- Practical Potato Special.
- Farmer's Friend,
- Vegetable and Vine.

N. Roy & Son, South Attleborough, Mass.: —
- Complete Animal Fertilizer.

The Rogers & Hubbard Co., Middletown, Conn.: —
- Soluble Potato Manure.
- Soluble Tobacco Manure.
- Fairchild's Formula for Corn and General Crops.
- Fruit Fertilizer.
- Grass and Grain Fertilizer.
- Oats and Top-dressing Fertilizer.
- Pure Raw Knuckle Bone Flour.
- Strictly Pure Fine Bone.
- Fertilizer for all Soils and all Crops.

Russia Cement Co., Gloucester, Mass.:—
- X X X Fish and Potash.
- High-grade Superphosphate.
- Corn, Grain and Grass Manure.
- Potato, Root and Vegetable Manure.
- Special Tobacco Fertilizer.
- Odorless Lawn Dressing.

Lucien Sanderson, New Haven, Conn.:—
- Formula A.
- Blood, Bone and Meat.
- Dissolved Bone-black.
- Nitrate of Soda.
- Sulphate of Potash.
- Muriate of Potash.

Edward H. Smith, Northborough, Mass.: —
  Ground Bone.

J. Stroup & Son Co., Boston, Mass.: —
  Hard-wood Ashes.

Thomas L. Stetson, Randolph, Mass.: —
  Ground Bone.

Standard Fertilizer Co., Boston, Mass.: —
  Standard Fertilizer.
  Potato and Tobacco Fertilizer.
  Standard Guano.
  Complete Manure.
  Fine-ground Bone.

C. F. Sturtevant, Hartford, Conn: —
  Tobacco and Sulphur Fertilizer.

Henry F. Tucker, Boston, Mass.: —
  Original Bay State Bone Superphosphate.
  Imperial Bone Superphosphate.
  Special Potato Fertilizer.

I. P. Thomas & Son Co., Philadelphia, Pa.: —
  Martin's Bone Mixture.
  So. Carolina Phosphate with Potash.
  So. Carolina Phosphate.
  Pure Ground Animal Bone.
  Steamed Bone.
  Improved Superphosphate.
  Potato and Tomato Manure.
  Normal Bone Phosphate.
  Farmer's Choice Bone Phosphate.
  Tobacco Fertilizer.

Walker, Stratman & Co., Pittsburg, Pa.: —
  Potato Special.
  Big Bonanza.
  Smoky City.
  Four Fold.

Andrew H. Ward, Boston, Mass.: —
  Ward's Chemical Fertilizer.

I. S. Whittemore, Wayland, Mass.: —
  Complete Manure.

D. Whithed, Lowell, Mass.: —
  Champion Fertilizer.
  Bone Meal.

The Wilcox Fertilizer Works, Mystic Conn.: —
  Potato, Onion and Tobacco Manure.
  Ammoniated Bone Phosphate.
  High-grade Fish and Potash.
  Dry Ground Fish Guano.

Williams & Clark Fertilizer Co., Boston, Mass.: —
  Ammoniated Bone Superphosphate.
  Potato Phosphate
  High-grade Special.
  Fine Wrapper Tobacco Grower.
  Royal Bone Phosphate.
  Corn Phosphate.
  Potato and Tobacco Manure.
  Grass Manure.
  Fish and Potash.
  Universal Ammoniated Dissolved Bone.
  Prolific Crop Producer.
  Onion Manure.
  Bone Meal.
  Dry Ground Fish.
  Sulphate of Potash.
  Muriate of Potash.
  Nitrate of Soda.
  Dissolved Bone-black.
  Sulphate of Ammonia.

M. E. Wheeler & Co , Rutland, Vt.: —
  High-grade Corn Fertilizer.
  High-grade Potato Manure.
  Superior Truck Fertilizer.
  Havana Tobacco Grower.
  High-grade Fruit Fertilizer.
  High-grade Grass and Oats Fertilizer.
  Electrical Dissolved Bone.

II. REPORT ON GENERAL WORK IN THE CHEMICAL LABORATORY.

CHARLES A. GOESSMANN.

1. Analyses of Materials sent on for Examination.
2. Notes on Barn-yard Manure.
3. Notes on Wood Ashes.
4. Notes on Cotton-seed Meal.
5. Notes on Guano from West Coast of Africa.
6. Notes on Ashes from Crematory Furnace for City Garbage.
7. Notes on Wool Washings.

1. Analyses of Materials sent on for Examination.

The work carried on in this connection is growing from year to year in importance. A large proportion of commercial manurial substances consists of by or waste products of various industries. The composition and general character of these materials depend on the current mode of manufacture. The rapid advancement in many branches of industries is at any time liable to affect more or less seriously the commercial as well as the manurial value of their waste products. A frequent examination of that class of materials cannot fail to benefit the vital interests of our farming community. For this reason arrangements were made, as in previous years, to attend to the examination of substances of interest to farmers to the full extent of the resources placed at the disposal of the officer in charge of this work. These investigations are carried on free of charge to farmers of the State. The results are considered public property, and are published from time to time in the bulletins of the station.

The number of substances tested in this connection amount to two hundred and thirty-eight. As the detailed results of their analyses have already been published in three bulletins, Nos. 45, 48 and 49, March, July and November, 1897, a brief statement of the names of the different articles analyzed will, on this occasion, suffice to convey some idea of the extent and the character of the work accomplished. Only a few of these materials of more special importance are reserved for a subsequent short discussion.

The substances tested from Dec. 1, 1897, to Dec. 1, 1898, are as follows: wood ashes, 89; cotton-seed meal, 23; cotton-seed hull ashes, 3; cotton factory waste, 5; tankage, bone and fish, 17; muck, peat and soils, 16; chemicals, 14; acid phosphates and dissolved bone-blacks, 5; natural phosphates, 6; tobacco refuse, 2; complete fertilizers, 31; miscellaneous, 9; Damara land guano, garbage cremation ashes and wool washings, each 1.

Aside from this work are the complete analyses of 36 samples of tobacco leaves, together with numerous tests for the quality of ash and rate of combustion. See Bulletin No. 47, on tobacco experiments, published in April, 1897.

The responsibility of the genuineness of all articles sent on for examination rests with the parties asking for the analysis. Our publications of the results refer merely to the locality they come from, to avoid misunderstandings. Samples of fertilizers collected from original packages by authorized agents of the station in the general markets furnish the material for official analyses, and are considered genuine articles.

2. Notes on Barn-yard Manure.

The importance of barn-yard manure as a home source of plant food cannot be over-estimated in a mixed farm management. In a well-regulated rational system of stock feeding it is one of the cheapest if not the cheapest source of valuable manurial constituents. An exceptional liability to vary in composition is the strongest objection which can be raised against its exclusive use as a manure supply for the farm and garden, yet this objection has lost much of its force since the causes of variation are better understood, and may thus be avoided to a considerable extent. We have learned how to improve its efficiency as a complete manure under varying conditions of soil as well as of varying wants of crops, by adding those manurial constituents which are called for in different relative proportions, and which the barn-yard manure on hand does not contain.

Analyses of Eighty Samples of Barn-yard Manure made at Amherst, Mass.

ANALYSIS.	POUNDS PER HUNDRED.			Pounds per Ton (2,000 Pounds).
	Highest.	Lowest.	Average.	
Moisture,	75.00	60.00	67.24	1344.80
Nitrogen,	1.36	.21	.52	10.40
Potassium oxide,	1.40	.13	.56	11.20
Phosphoric acid,	.75	.10	.39	7.80

The average barn-yard manure contains, as will be noticed from the above statement, a larger percentage of nitrogen as compared with potash and phosphoric acid than is generally considered economical in a complete fertilizer for general farm purposes.

The practice of adding to the manurial refuse materials of the farm, as stable manure, vegetable compost, etc., such single commercial manurial substances as will enrich them in the direction desirable for any particular crop, does not yet receive that degree of general attention which it deserves. An addition of potash in the form of muriate or sulphate of potash, or of phosphoric acid in the form of fine-ground South Carolina or Florida soft phosphate, etc., will in many instances not only improve their general fitness as complete manure, but quite frequently permit a material reduction in the amount of barn-yard manure ordinarily considered necessary to secure satisfactory results. An addition of from thirty to forty pounds of muriate of potash and one hundred pounds of fine-ground soft Florida phosphate per ton of barn-yard manure, at any time before applying the latter to the soil deserves recommendation.

3. Notes on Wood Ashes.

Forty per cent. of all articles sent on for examination consist of wood ashes. They are sold in the majority of cases under the trade name "Unleached Canada hard-wood ashes." Ninety-eight samples tested at the station during the past year gave the following results: —

		No. of Samples.
Moisture from 1 to 3 per cent.,		10
" 4 to 6 "		8
" 6 to 10 "		13
" 10 to 15 "		19
" 15 to 20 "		11
" 20 to 30 "		10
Moisture above 35 per cent.,		1
Potassium oxide above 8 per cent.,		3
" " from 7 to 8 per cent.,		8
" " " 6 to 7 "		21
" " " 5 to 6 "		28
" " " 4 to 5 "		10
" " " 3 to 4 "		3
" " below 3 per cent.,		none
Phosphoric acid above 2 "		4
" " from 1 to 2 per cent.,		45
" " below 1 per cent.,		24
Average per cent. of calcium oxide (lime),		34.29
Per cent. mineral matter insoluble in diluted hydrochloric acid, from —	6 to 10,	10
	10 to 15,	30
	15 to 20,	15
	20 to 30,	3
	above 30,	1

The variations noticeable in the composition of wood ashes are not surprising when we consider the crude mode of collecting and handling them for commercial purposes. The particular effects of both varying quantities of foreign insoluble matter, as soil, coal ashes, etc., and of moisture, on the composition of a given sample of genuine wood ashes, as far as its percentage of potash and of phosphoric acid is concerned, depend largely on the particular kind of wood which has served for the production of the ash. The color of the wood ashes in case of dark varieties depends usually on admixture of more or less charcoal, while an exceptionally light color is not unfrequently due to the kind of wood which furnishes it. Some kinds of wood, as elm wood, produce a white ash of excellent quality, judging from samples sent on for examination.

As the dealer is only obliged to guarantee the amount of potash and of phosphoric acid present in a given quantity of wood ashes, no serious objection can be raised on the part of the buyer on account of moisture, etc., as long as the article contains the specified amount of both potash and phosphoric acid.

Wood ashes ought to be bought and sold by weight, and not by measure, for both moisture and foreign matters are apt to affect seriously the weight of a given measure.

Some dealers in wood ashes have adopted of late the practice of stating merely the sum of both, instead of specifying the amount of each of them present. As phosphoric acid and potassium oxide contained in wood ashes are considered in our section of the country, pound for pound of an equal commercial value, from 4.5 to 5 cents, no particular objection can be raised against a joint statement of both as far as the mere money value of the samples is concerned; yet, as this mode of stating the guaranteed composition is apt to lead to misconception and abuse, it ought to be discouraged and discontinued.

The large percentage of lime, from 30 to 40 per cent., found in genuine wood ashes, imparts a special agricultural value to them as a fertilizer, aside from the amount of potash and phosphoric acid they contain. Wherever an application of lime is desired, wood ashes deserve favorable consideration, on account of the superior mechanical condition of the lime they furnish.

4. Notes on Cotton-seed Meal as a Fertilizer.

Recent low prices of some concentrated feed stuffs have favored experiments to test their fitness for supplying directly nitrogen, phosphoric acid and potash for plant food. Whenever the market value of the amount of nitrogen, phosphoric acid and potash they contain compares fairly well with the market cost of these three ingredients, the trials deserve, for various reasons, encouragement.

The richness of cotten-seed meal, linseed meal, etc., as well as their marked disposition to rot in the presence of moisture and of a fair average temperature, caused their selection. Both are quite frequently looked upon with favor as suitable materials to furnish plant food for various farm crops. Cotton-seed meal in particular is to-day used extensively by tobacco growers in the Connecticut River valley as the main source of nitrogen for that crop.

The increasing importance of cotton-seed meal as a fertilizer has been followed by the writer with a frequent examination of the articles sold in our markets to protect the interests of our farmers. Importers of cotton-seed meal, claiming that they sold their articles as a feed stuff and not as a fertilizer, declined as a rule until quite recently to take out a fertilizer license which would oblige them to sell with a stated guarantee of at least the nitrogen.

The results of sixty-five analyses carried on under my direction are as follows : —

	Per Cent.		
	Maximum.	Minimum.	Average.
Moisture,	10.80	3.90	7.00
Nitrogen,	7.95	2.08	6.60
Phosphoric acid,	3.36	.73	1.79
Potassium oxide,	2.38	.48	1.76

Allowing 12 cents for every pound of nitrogen, 5 cents per pound for each of phosphoric acid and potassium oxide, these three ingredients represent per ton a market value of —

$19.39 in case of our average sample of cotton-seed meal.
24.82 in case of our highest sample of cotton-seed meal.
6.20 in case of our lowest sample of cotton-seed meal.

The above-stated difference in the composition of cotton-seed meal is mainly due to the presence of more or less ground skins and husks of the cotton seed. Cotton-seed meal designed for fodder ought to be free from skins and husks, to deserve a recommendation for that purpose ; cotton-seed meal to be used for fertilizer may contain more or less of this substance, provided the entire material is finely ground and the price in accordance with the composition.

We advise farmers to buy cotton-seed meal, like all other fertilizing materials, on the basis of a guarantee of (at least) nitrogen as the basis of the bargain. For their information it seems but proper to state in this connection that the American Cotton Oil Company of New York has quite recently secured a license for the sale of their cotton-seed meal as a fertilizer in our State, and intend to sell on the basis of the amount of nitrogen their article contains.

5. NOTES ON DAMARA LAND GUANO.

The material which served for our examination was sent on to this office by Messrs. H. J. Baker & Bro. of New York City. It consisted of a bag containing two hundred pounds of guano, and was accompanied by analyses of two chemists of London, Eng. As every new source of a genuine guano claiming to resemble the Peruvian guano of earlier periods in the trade of commercial fertilizers must be of special importance to all interested in the temporary resources of our supplies of plant food, our results are briefly stated below: —

Analysis of Damara Land Guano (Per Cent.).

Moisture at 100° C.,	17.70
Organic matter,	25.63
Total ash,	56.67
Total nitrogen,	5.79
Nitrogen in form of ammoniates,	1.80
Nitrogen in form of nitrates,	.05
Nitrogen in form of organic matter,	3.94
Carbonic acid,	trace
Total phosphoric acid,	14.78
Soluble phosphoric acid,	4.90
Reverted phosphoric acid,	5.79
Insoluble phosphoric acid,	4.09
Total potassium oxide,	3.53
Potassium oxide soluble in water,	3.46
Sodium oxide,	7.03
Calcium oxide,	14.21
Magnesium oxide,	2.05
Iron and aluminum oxides,	trace
Sulphuric acid,	5.94
Chlorine,	5.77
Insoluble matter,	9.26

The results of our analyses of the sample (two hundred pound bag) kindly sent on for trial by Messrs. H. J. Baker & Bro., New York City, are fairly within the stated composition of English chemists. The guano, it is stated, has been brought from some islands off the west coast of Africa; it is a valuable material, as may be seen from our detailed statement.

6. Notes on Crematory Ashes from City Garbage.

In my annual report for 1895 (pages 160 and 161), special attention was called to two important recent modes of saving city garbage, kitchen refuse in particular, for manurial purposes. Sanitary considerations are the first cause of the introduction of these new modes of disposing of objectionable refuse matter, which promise to become from day to day more important as supplies of valuable fertilizer materials.

Our attention has been in particular called to the products of the crematory furnace ashes from Lowell, Mass. The article is evidently improving, in consequence of the adoption of a proper system of sifting and grinding the ashes, as will be seen from the accompanying analysis, representing, according to statement, one hundred tons. The selling price, from $10 to $11 per ton, invites serious trials, as a fertilizer furnishing potash, phosphoric acid and lime.

Analysis of Ashes from the Cremation of City Garbage (Per Cent.).

Moisture at 100° C.,	.53
Potassium oxide,	6.01
Sodium oxide,	15.65
Total phosphoric acid,	10.21
Available phosphoric acid,	2.34
Insoluble phosphoric acid,	7.87
Sulphuric acid (So_3),	4.57
Chlorine,	4.75
Carbonic acid (CO_2),	10.85
Calcium oxide,	20.22
Magnesium oxide,	1.16
Iron and alumina,	9.32
Insoluble matter,	24.26
Nitrogen (inactive lyan compounds),	.17

7. Notes on Wool Washings as a Source of Fertilizer.

It is a well-known fact that the skins of sheep and raw wool are coated with potash compounds of a soap-like nature. In many localities in Europe it is a common practice to turn to account for manuring grass lands the water used in washing sheep before shearing, as well as the wash water obtained from raw wool in factories. This is used in form of an overflow. Wherever meadows adjoin the place of washing wool, arrangements may be readily provided for turning the wool washings directly to account. Samples of raw wool tested here for potash some years ago gave the following results: —

Potassium oxide soluble in water (per cent.),	3.92
Potassium oxide soluble in diluted hydrochloric acid (per cent.),	4.20

Of interest in this connection are the results of examination of a material sent on from a factory in this State. The article was labelled "concentrated potash liquor," and described as obtained from the washings of wool with water after the grease had been extracted by naphtha. It consisted of a highly colored, thick, syrup-like mass, containing a liberal admixture of fine fibrous vegetable matter. An analysis made with reference to its approximate value as a fertilizer gave the following results: —

	Per Cent.
Moisture at 100° C.,	41.13
Dry matter,	58.87

The dry matter left behind contained: —

	Per Cent.
Potassium oxide,	10.15
Phosphoric acid,	.10
Nitrogen,	1.09

The commercial value of these ingredients per ton of the original substance at the present rates amounts approximately to $12.40. In charring the original material directly, 100 parts left behind 36.49 parts; the charred mass tested for potassium oxide showed 34.91 per cent. present, or 698.2 pounds of potassium oxide per ton of charred residue, which equals 1,012 pounds of carbonate of potash per ton of charred residue practically free from chlorine.

The scarcity of a good quality of carbonate of potash for manurial purposes in case of tobacco and similar industrial crops ought to encourage attempts to turn the concentrated potash liquor to account.

The charred mass might serve directly as material for the manufacture of a high-grade potash fertilizer.

III. NOTES OF FIELD EXPERIMENTS WITH TOBACCO IN MASSACHUSETTS, 1893–96.

CHARLES A. GOESSMANN.

The experiments briefly described in the following pages were carried on with the co-operation of the Valley Tobacco Experiment Association of Massachusetts.

The officers of this organization consisted of President L. A. Crafts of Whately, Vice-President C. L. Fowler of Westfield, Secretary and Treasurer G. D. Fisk of Agawam; Board of Directors, W. A. Porter of Agawam and C. L. Warner of Hatfield.

Hatfield, Westfield and Agawam were chosen for the location of the experiments. The selection of the particular field in each place was left to a special committee of the association. In all cases a deep, sandy loam was selected for the trial.

The same kind and the same amount of fertilizing ingredients were used in all cases, and the observations continued for three successive years. For details see Bulletin No. 47, April, 1897.

The variety of tobacco selected for the trial was Havana seed. For the purpose of securing uniformity of fertilizer during the years of the experiment, it was decided to purchase at once, as far as advisable, enough of each kind to supply the needed materials for three years.

Statement of Fertilizers used upon Different Plots.

The fertilizer mixture used during the entire time of observation contained in all cases, per acre: —

	Pounds.
Potassium oxide (available)	300
Nitrogen (available),	100
Phosphoric acid (available),	60

One-fourth of the nitrogen was in all cases used in the form of nitrates of soda or potash, to secure a uniform condition of availability of nitrogen during the early stages of growth.

Each experiment plot measured 3,634 square feet, or approximately one-twelfth of one acre.

Chemical Composition of the Different Fertilizing Ingredients used in compounding the Special Fertilizers for Different Plots in the Tobacco Experiment. Ingredients containing Chlorine were carefully excluded from the Mixtures of Fertilizers in All Cases.

NAME OF MATERIAL.	Nitrogen.	Phosphoric Acid.	Potassium Oxide.	Sodium Oxide.	Calcium Oxide.	Magnesium Oxide.
Nitrate of soda,	15.59	–	–	35.00	–	–
Nitrate of potash,	12.79	–	45.05	–	–	–
Cotton-seed meal,	6.50	3.17	2.25	–	–*	–*
Linseed meal,	5.91	1.95	1.08	–	–*	–*
Castor pomace,	5.60	2.26	3.40	–	–*	–*
Dissolved bone-black,	–	13.38	–	–	–*	–
Odorless phosphate, or phosphatic slag,	–	18.42	–	–	48.27	–
High-grade sulphate of potash,	–	–	50.20	–	–	–
Potash-magnesia sulphate,	–	–	24.32	–	–	12.58
Cotton-seed hull ashes,	–	7.93	23.96	–	9.30	10.47
Carbonate of potash-magnesia,	–	–	18.48	–	–	19.52
Barn-yard manure,	.52	.39	.56	–*	–*	–*

* Not determined.

Chemical Composition of the Different Special Formulas used in the Tobacco Experiment.

PLOT 1.

NAME OF FERTILIZING MATERIAL USED.	Pounds per Acre.	POUNDS OF FERTILIZING ELEMENTS PER ACRE.		
		Phosphoric Acid.	Potassium Oxide.	Nitrogen.
Nitrate of potash,	195	–	88	25
Cotton-seed meal,	1,154	37	26	75
Dissolved bone-black,	175	23	–	–
Potash-magnesia sulphate,	765	–	186	–
Total,	–	60	300	100

Plot 2.

NAME OF FERTILIZING MATERIAL USED.	Pounds per Acre.	Pounds of Fertilizing Elements per Acre.		
		Phosphoric Acid.	Potassium Oxide.	Nitrogen.
Nitrate of potash, ...	195	–	88.0	25
Castor pomace, ...	1,340	31	45.0	75
Dissolved bone-black, . . .	221	29	–	–
Potash-magnesia sulphate, . .	685	–	166.5	–
Total, ...	–	60	299.5	100

Plot 3.

Nitrate of soda, ...	160.3	–	–	25
Cotton-seed meal, ...	1,154.0	37.00	26	75
Cotton-seed hull ashes, . . .	1,142.0	90.56	274	–
Total, ...	–	127.56	300	100

Plot 4.

Nitrate of soda, ...	160.3	–	–	25
Castor pomace, ...	1,340.0	31.0	45.50	75
Cotton-seed hull ashes, . . .	1,060.0	84.1	253.97	–
Total, ...	–	115.1	299.47	100

[Plot 5.—No manure at any time during the experiment.]

Plot 6.

Nitrate of soda, ...	160.3	–	–	25
Cotton-seed meal, ...	1,154.0	37	26	75
Dissolved bone-black, . . .	175.0	23	–	–
High-grade sulphate of potash, .	545.8	–	274	–
Total, ...	–	60	300	100

PLOT 7.

NAME OF FERTILIZING MATERIAL USED.	Pounds per Acre.	POUNDS OF FERTILIZING ELEMENTS PER ACRE.		
		Phosphoric Acid.	Potassium Oxide.	Nitrogen.
Nitrate of soda,	160.3	–	–	25
Castor pomace,	1,340.0	31	45.50	75
Dissolved bone-black,	221.0	29	–	–
High-grade sulphate of potash,	506.0	–	254.50	–
Total,	–	60	300.00	100
PLOT 8.				
Nitrate of soda,	160.3	–	–	25
Linseed meal,	1,271.0	24.78	14	75
Dissolved bone-black,	263.0	35.22	–	–
High-grade sulphate of potash,	569.7	–	286	–
Total,	–	60.00	300	100
PLOT 9.				
Nitrate of potash,	195	–	88	25
Cotton-seed meal,	1,154	37	26	75
Cotton-seed hull ashes,	776	62	186	–
Total,	-	99	300	100
PLOT 10.				
Nitrate of potash,	195.0	–	88.00	25
Castor pomace,	1,340.0	31	45.50	75
Phosphatic slag meal,	157.0	29	–	–
Carbonate of potash-magnesia,	900.9	–	166.50	–
Total,	–	60	300.00	100
PLOTS 11 AND 12.*				
Barn-yard manure,	20,000	78	112	104

---

* Average analysis of seventy-five samples tested at the station laboratory at Amherst, Mass.

Summary of Three Years of Observation at Hatfield, Agawam and Westfield.

I. Number of Plants harvested and Yield of Tobacco per One Thousand Plants.

Hatfield (Old Tobacco Land).

YEAR.	AVERAGE NUMBER OF PLANTS.		DIFFERENCE IN YIELD PER PLOT ON THE BASIS OF 1,000 PLANTS (POUNDS).	
	Per Plot.*	Per Acre.	Highest.	Lowest.
1893, ...	561	6,734	266	217
1894, ...	618	7,419	223	191
1895, ...	626	7,512	222	191

* One-twelfth of one acre.

Westfield (New Tobacco Land).

1894, ...	670	8,040	192	155
1895, ...	593	7,122	245	217
1896, ...	689	8,269	216	191

Agawam (New Tobacco Land).

1893, ...	696	8,352	225	158
1894, ...	704	8,432	220	164
1895, ...	695	8,340	222	148

YEAR.	AVERAGE YIELD OF TOBACCO ON THE BASIS OF 1,000 PLANTS HARVESTED (POUNDS).		
	Hatfield.	Westfield.	Agawam.
1893, ...	235.2	–	191.3
1894, ...	206.4	171.6	186.7
1895, ...	210.5	228.0	176.2
1896, ...	–	199.4	–

II. *Average Yield of Tobacco, with Reference to Wrapper, per One Thousand Plants.*

Hatfield.

YEAR.	Average Yield of Tobacco.	Average Yield of Wrappers.	Average Percentage of Wrappers.	Variations in Percentage of Wrappers in Plots.
	Pounds.	Pounds.		
1893, ...	235.2	97.2	41.2	21.0-71.0
1894, ...	206.6	105.0	50.7	38.8-64.4
1895, ...	210.1	109.3	52.1	36.8-63.1
Westfield.				
1894, ...	171.3	90.3	52.3	41.6-62.10
1895, ...	228.7	49.6	21.2	6.4-34.40
1896, ...	199.3	138.2	69.6	59.0-78.80
Agawam.				
1893, ...	190.8	-*	-*	-*
1894, ...	191.7	52.2	26.7	8.8-44.4
1895, ...	178.8	-*	-*	-*

* Not determined.

CONCLUSIONS DRAWN FROM THE THIRD YEAR OF OBSERVATION.

1. Good mechanical preparation of the soil and early application, and thus good diffusion of the fertilizers, not less than early planting and a suitable number of plants to a given area, exert a decided influence on the quantity and the quality of the crop, under otherwise corresponding conditions. Planting as early as the local climate admits secures the benefit of the winter moisture.

Too close planting interferes with a liberal or rapid development of the leaves, and too large open spaces between the individual plants tends to favor a coarser structure. Rows three feet and four inches apart with plants twenty inches from each other in the row (Westfield), and rows two feet and eight inches apart with plants two feet from each other in the row (Hatfield) gave better returns than rows three feet apart with plants eighteen inches from each other in the row (Agawam).

2. A timely, shallow use of the cultivator or hoe for the removal of weeds favors a uniform progress of growth. A careless use of cultivator or hoe invariably checks more or less the growth of the plants, and modifies more or less their structure and general character.

3. The different fertilizer mixtures used in our experiments have affected in a less marked degree the weight of the crop raised by their aid than the quality. New lands reduced by previous cropping to a state approaching general exhaustion of available plant food, if otherwise well fitted for raising tobacco, have given excellent results when supplied with a suitable mixture of fertilizing ingredients in quantities similar to those applied during our experiments (Westfield). Such lands are at times preferable to old tobacco lands overcharged with remnants of all kinds of saline ingredients, usually associated with the common run of commercial fertilizers.

4. Cotton-seed meal, linseed meal and castor pomace have proved equally good sources of nitrogen for the successful raising of tobacco when used in connection with nitrate of soda or potash, sufficient to furnish one-fourth of the nitrogen called for by the crop.

5. Nitrate of soda as a part of the nitrogen supply in the fertilizer (25 per cent.), when used in presence of acid phosphate, dissolved bone-black, etc., has been accompanied with better results regarding quality of crop than nitrate of potash under otherwise similar conditions.

6. Cotton-seed hull ashes and high-grade sulphate of potash have proved in our observation most valuable sources of potash for tobacco, the former in the majority of cases leading. Nitrate of potash has produced excellent results when used in connection with an alkaline phosphate, as phosphatic slag meal or with carbonate of potash-magnesia. Our

results with potash-magnesia sulphate as the main potash sources of a tobacco fertilizer are not encouraging.

7. The difference noticed in the color of ash, etc., in case of the crop being raised upon different plots, is in several instances so slight that an attempt to classify the various fertilizers used with reference to their superior fitness on the basis of color and compactness of ash cannot be otherwise than arbitrary. With this qualification in mind, the following classification is offered for the consideration of parties engaged in the cultivation of tobacco in our section of the country: —

First Class.

Plot 4. — Nitrate of soda, cotton-seed hull ashes and castor pomace.

Plot 3. — Nitrate of soda, cotton-seed hull ashes and cotton-seed meal.

Plot 9. — Nitrate of potash, cotton-seed hull ashes and cotton-seed meal.

Plot 10. — Nitrate of potash, carbonate of potash-magnesia and phosphatic slag.

Second Class.

Plot 6. — Nitrate of soda, high-grade sulphate of potash, cotton-seed meal and dissolved bone-black.

Plot 8. — Nitrate of soda, high-grade sulphate of potash, linseed meal and dissolved bone-black.

Plot 7. — Nitrate of soda, high-grade sulphate of potash, castor pomace and dissolved bone-black.

Third Class.

Plot 1. — Nitrate of potash, potash-magnesia sulphate, cotton-seed meal and dissolved bone-black.

Plot 2. — Nitrate of potash, potash-magnesia sulphate, castor pomace and dissolved bone-black.

The observations with barn-yard manure have not been considered in the above classification; they are very encouraging, but not sufficient in number to permit detailed discussion in this connection; besides, the amount of barn-yard manure used in our experiment, ten tons per acre, contained nearly two hundred pounds of potassium oxide and from thirty to forty pounds of available phosphoric acid less than our formula of commercial fertilizing ingredients called for.

An early application of barn-yard manure, properly supplemented with a suitable potash compound and available phosphoric acid, has produced excellent results in other localities.

INDEX.

PAGE
Agriculturist, report of, 171
Alfalfa, 197
Ashes, wood, notes on, 283
  Crematory, from city garbage, 287
Asparagus rust, 220
Barn-yard manure, notes on, 281
Black chaff or African millet, 199
Botanists, report of, 209
Brazillian stooling flour corn, 199
Brown rot of stone fruits, 225
Butternut, leaf blight of, 231
Chemist (fertilizers), report of, 268
Chemist (foods and feeding), report of, 236
Cherry, wild black, leaf spot of, 232
Chestnut, leaf spot of, 231
Chrysanthemum rust, 227
Clovers, 195
  Alsike, 195
  Crimson, 198
  Mammoth, 195
  Medium red, 195
  Sweet, 195
Corn, variety tests of, 190
Cotton-seed feed as hay substitute, 241
  Composition of, 244
  Digestibility of, 245
  Feeding experiments with, 247
Cotton-seed meal as fertilizer, 284
Damara land guano, 286
"Drop" of lettuce, 217
Entomologist, report of, 264
FERTILIZERS:
  Ashes, wood, notes on, 283
  Ashes, crematory, from city garbage, 287
  Comparison of different phosphates, 178
  Cotton-seed meal as fertilizer, 284
  Damara land guano, 286
  For beets, 187
  For celery, 187
  For garden crops, 185
  For peas, 186
  For squashes, 187
  Injurious effect of sulphate of ammonia and muriate of potash used together, 188
  Manure *v.* manure and potash, 173

FERTILIZERS — *Concluded.* PAGE
  Muriate compared with sulphate of potash in connection with sulphate of ammonia for corn, ... 184
  Natural phosphates compared with each other and with acid phosphate, . 176
  Special corn fertilizer *v.* fertilizer richer in potash, ... 174
  Sulphate of iron as a fertilizer, ... 189
  Trade values of fertilizer ingredients, ... 274
  Wool washings as fertilizer, ... 288
Fire blight, ... 222
Formaldehyde gas as fungicide, ... 211
Geranium, disease of, ... 229
Grasses, variety tests of, ... 191
Grass land, manuring of, ... 188
Horticulturist, report of, ... 233
Hydrocyanic gas as fungicide, ... 211
Idaho field or coffee pea, ... 198
Meteorologist, report of, ... 207
Millets, ... 193
  Panicum crus-galli, ... 194
  Panicum italicum, ... 195
  Panicum miliaceum, ... 194
NITROGEN:
  Leguminous crops as nitrogen gatherers, ... 181
  Nitragin, ... 188
  Relative value of different manures furnishing nitrogen, ... 183
Potato crop (1897), causes of failure, ... 214
Potatoes, variety tests of, ... 190
Poultry experiments, ... 199
  Condition powder for producing eggs, ... 200
  Cut bone *v.* animal meal for producing eggs, ... 203
  Clover rowen *v.* cabbage for producing eggs, ... 204
Quince rust, ... 223
Saccaline, ... 197
Soil tests, ... 171
  With corn, ... 172
  With potatoes, ... 172
Soya beans, ... 195
Spraying as preventive of diseases, ... 212
Stumps, reputed method of destroying, ... 199
Sycamore, leaf blight of, ... 230
Tobacco, field experiments with, ... 290
Treasurer's report, ... 169
Winter vetch, ... 198